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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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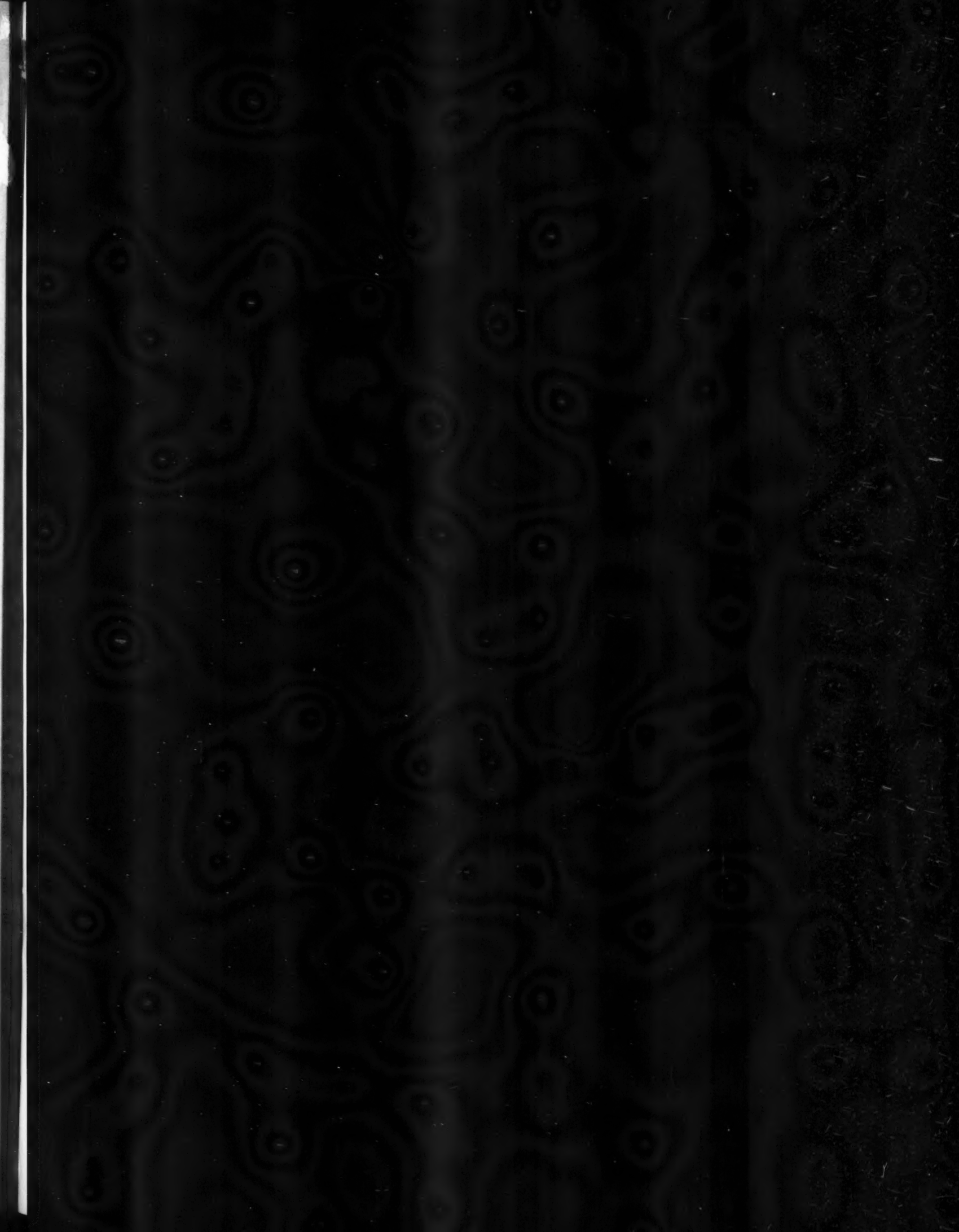


A NEW THEORY OF THE STEAM TURBINE.

By HAROLD MEDWAY MARTIN, Wh.Sc., A.C.G.I.

(*Continued from page* 162.)

FROM the results established in the last article it is obvious that the thermal equilibrium of expanding steam cannot be immediately re-established when condensation takes place at the Wilson line. As pointed out in the introductory article, there were some grounds for anticipating this conclusion both from theoretical considerations and from the results of Wilson's experiments. Wilson found (Phil. Trans., vol. clxxxix, page 305) that the number of droplets formed in his experiments on the expansion of supersaturated vapour increased enormously when the expansion was continued beyond the Wilson point.

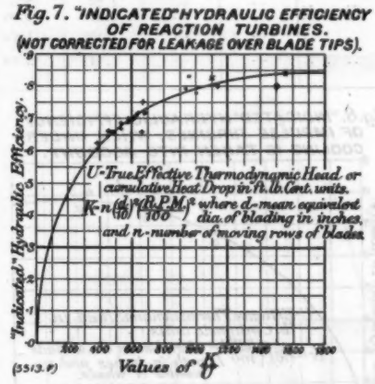
The condensation was accordingly occurring not on the droplets already formed but on new nuclei, and the temperature of the expanding vapour must accordingly have been not higher than that of the Wilson point corresponding to the pressure. There was thus a high degree of under-cooling up to the very end of the expansion. For the reasons set forth on page 1 *ante* it is impossible to measure the temperature of this under-cooled steam by means of a thermometer.

Possibly the failure of the droplets already formed to serve as condensation nuclei when the expansion is continued beyond the Wilson line is in part due to questions of conductivity; but the influence of this factor would seem to be small, and the cause for the lag in the establishment of thermal equilibrium therefore must be sought elsewhere, and it seems probable that it is due to the fact that the energy liberated on condensation does not in the first instance take the form of heat energy.

A vapour condenses because of the mutual attraction between its molecules. This attraction is electrical in origin and differs in degree rather than in kind from the attractions which are concerned in the formation of chemical compounds. In that case chemists have long been of the opinion that the energy which is ultimately observed in the form of heat is in the first place set free in another form, and that this energy, consisting in the vibration or other motion of the electrons, is only comparatively slowly transferred from the light electron to the heavy molecule. Heat is a molecular motion, and until this transfer is effected the energy involved does not appear as heat. The observations made by the British Association Committee on Gaseous Explosions have shown that gases are fairly transparent to their own radiations,* and that quite a sensible time is required for transferring as heat to the molecule of the gas, the energy liberated by the act of combustion.

It has been shown in the preceding article that the assumption that the steam expands in thermal equilibrium when the expansion is carried beyond the Wilson line is inconsistent with experience, which is thus in accord with Wilson's observation that the condensation which comes down during such an expansion separates out on fresh nuclei. In making this comparison the same efficiency curve was used as in the previous calculation, in which it was assumed that thermal equilibrium was established at the saturation line and subsequently maintained. This curve is less well defined than is desirable, and for the future the curve for reaction turbines reproduced in Fig. 7 will be used. The writer has to thank various friends for the data on which this curve is based. Many of the results plotted in the earlier portions of this curve were obtained in progressive trials of a steam turbine run at different speeds and with different superheats. In this series of experiments which were made almost under laboratory conditions the steam was highly superheated so that "indicated" efficiencies could be determined without various corrections for dummy and gland leakages and for frictional losses, which constitute a serious difficulty in deducing the indicated efficiencies of turbines from the usual test data. The temperatures were measured electrically and every precaution taken to secure as reliable figures as possible. In any case, even if the efficiencies recorded may not be "absolute" results, they are relatively reliable *inter se*, and give correctly the shape of the efficiency curve in the region covered by the experiments. The other points are plotted from ordinary test data corrected for internal losses by the formulæ given on page 107 *ante*. Some of the points, it will be seen, are erratic, and further data for high values of $\frac{K}{U}$ would be particularly welcome. Unfortunately, tests are sometimes made with a view to establishing a record rather than the actual facts. Recently, moreover, turbines have been built giving their maximum economy, at 80 per cent. of their rated load, and comparisons with previous tests are accordingly complicated. Again, owing presumably to a desire to cut costs, certain recent turbines have cramped exhaust ends, and consequent excessive losses by carry over. Attempts have been made to recover part of the energy thus wasted by diffusers, but so far as the writer is aware wherever these diffusers have been fairly tested the results have been wholly unsatisfactory. Certainly every diffuser so far fitted, of which particulars are available, appears to have had serious faults in design. In the case of some of the high points plotted in Fig. 7, the writer is informed that the test figures have not been confirmed in the actual operation of the turbines since they were put in service. No explanation has been found for some of the low points plotted. One builder states that of two turbines erected in the same station and built to the same drawings one has consistently proved materially less economical than the other. In a laboratory such a discrepancy would be cleared up, but few firms are prepared to investigate such anomalies thoroughly when they are met with in commercial work. On the whole the curve nevertheless, is believed to represent fairly accurately the relative efficiency of turbines as the ratio $\frac{K}{U}$ is increased. The value of U adopted was calculated from the chart, Plate I, published in our issue of July 5, 1918, using the equivalent reheat factors for expansions beyond the Wilson line. These equivalent reheat factors were arrived at along the following line of reasoning.

Fig. 7. "INDICATED" HYDRAULIC EFFICIENCY OF REACTION TURBINES. (NOT CORRECTED FOR LEAKAGE OVER BLADE TIPS).


"Indicated" Hydraulic Efficiency.
U-True Effective Thermodynamic Head, or cumulative Heat Drop in B.Th.Unit. units.
K=n(d.P.M./100)², where d=mean equivalent dia. of blading in inches, and n=number of moving rows of blades.
Values of K/U
(5513.F)

It is a fundamental axiom in thermodynamics that a gas, by suitable additions of heat, may be caused to expand according to any law, however arbitrary. It is thus possible, for example, by the use of appropriate reheat factors to make the volume and pressure of steam expanding without condensation exactly the same point for point as the volume and pressure of wet steam expanding in conditions of thermal equilibrium. The gross work done in this "equivalent" expansion is, moreover, the same as that done in the corresponding actual expansion of the wet steam.

To take a simple case, we know that when wet steam expands in conditions of thermal equilibrium the actual volume occupied by the steam depends upon the dryness fraction. Nevertheless the relation between volume and pressure can be represented with considerable accuracy by an expression of the form $p V^n = \text{constant}$. Thus, if at starting the steam were just dry, then according to Zeuner the expansion takes place according to the law $p V^{1.135} = \text{constant}$. By the methods explained on pages 53 and 54 *ante*, we can easily calculate a series of reheat factors which, if applied to super-heated or completely supersaturated steam, will give the same law of expansion.

If, then, u_s be the heat-drop corresponding to frictionless expansion in thermal equilibrium and u' the heat-drop if the frictionless expansion were made without condensation and in a state of complete supersaturation between the same initial and final pressures, we may write:

$$u_s = \overline{R}\, u'$$

where u_s is measured from the dotted lines of the steam chart, Plate I *ante*, and u' from the full-line curves.

Similarly, if instead of frictionless expansion the steam is utilised in a turbine working with an hydraulic efficiency η, we can establish an exactly similar relationship between an expansion in conditions of thermal equilibrium and an expansion in a state of complete supersaturation without condensation.

We have in the first instance for the cumulative heat-drop U_s the expression:

$$U_s = R_s\, u_s$$

where R_s is taken from Table III, page 54 *ante*, and the useful work done is $\eta R_s u_s$. But as has just been shown, we may replace u_s by $\overline{R}\, u'$, so that, as before, the useful work done and the relation between volume and pressure for the actual expansion in thermal equilibrium can, by the use of an appropriate reheat factor, be represented by an expansion (between the same limits) of steam which remains completely supersaturated.

In the real expansion the volume occupied by the steam is diminished owing to condensation; in the equivalent expansion this real defect in the mass actually gaseous is replaced by an equivalent but imaginary reduction in the temperature of the mass which is assumed to remain wholly in the state of vapour.

In the cases above discussed the limiting value of all the reheat factors involved is unity when the pressure ratio x is unity. If, however, the expansion starts at the Wilson line this is no longer the case. If thermal equilibrium be re-established at this line there is a sudden increase of 10 per cent. in the volume of the steam. This percentage increase is sensibly the same at whatever point the Wilson line be crossed.

Hence, if we wish to represent an expansion in thermal equilibrium from the Wilson line by an equivalent continued expansion without condensation, the reheat factor to be adopted will have the value 1·1 when $x = 1$.

Thus, let $p V'$ denote the pressure and volume of the steam on reaching the Wilson line. If, then, thermal equilibrium be re-established the pressure remains unchanged but the volume increases to a value $V_w = 1{\cdot}1\ V'$. The further expansion of this steam in thermal equilibrium can be represented as before by a law of the type $p V_w^{\beta} = \text{constant}$, and the useful work done in the expansion will be

$$\eta U_s = \frac{\beta \eta}{\beta - 1} \cdot \frac{144}{1400} \cdot p V_w \left(1 - \left(\frac{1}{x}\right)^{\frac{\beta - 1}{\beta}}\right)$$

ft.-lb. Centigrade units.

Substituting for $1{\cdot}1\ V'$ for V_w, this becomes:

$$\frac{1.1 \times 144}{1400} \cdot \frac{\beta \eta}{\beta - 1} \cdot p V' \left(1 - \left(\frac{1}{x}\right)^{\frac{\beta - 1}{\beta}}\right) = \eta \overset{*}{R}\, u'_w$$

where $\overset{*}{R}$ denotes the "equivalent" reheat factor and has the limiting value $1{\cdot}1$ when $x = 1$.

By drawing a condition line on the steam chart Plate I *ante*, we can determine the point at which the Wilson line is crossed whatever the initial conditions of the expansion, and also the value of U_s for the remainder of this expansion if effected in conditions of thermal equilibrium. Values of U_s for a number of different efficiencies are given in Table VII, page 162 *ante* for the case in which the steam had initially a stop-valve pressure of 195 lb. absolute and was expanded to a final pressure of 1 lb. absolute. We can also, by calculation or measurement from the chart, determine what the adiabatic heat-drop u'_w would have been had the expansion continued past

* Third Report of the Committee on Gaseous Explosions. ENGINEERING, September 9, 1910, page 382.

the Wilson line without friction and without condensation according to the laws expressing the behaviour of superheated or supersaturated steam.

We then have $\dot{R} = \frac{U_s}{u'}$.

Proceeding in this way we can calculate equivalent reheat factors for cases in which the turbine efficiency is, say, 0·5, 0·6, 0·7, or 0·8. The results are given in Table VIII. In this table the first line is taken from Table VII, page 162 *ante*. By "Wilson" pressure is denoted the pressure at which the Wilson line is crossed.

TABLE VIII.—Equivalent Reheat Factors for Expansion in Thermal Equilibrium from the Wilson Line. Stop-Valve Pressure, 195 Lb. Absolute; Initial Pressure, 180 Lb. Absolute; Final Pressure, 1 Lb. per Sq. In. Absolute.

	Hydraulic Efficiency η	0.5	0.6	0.7	0.8
No superheat	U_s F.P.C.	91.08	117.94	131.03	138.23
	u'_w F.P.C.	68.72	85.74	94.13	99.17
	Equivalent reheat factor— $\dot{R} = \frac{U_s}{u'_w}$	1.3255	1.4086	1.3922	1.3940
	Ratio $\frac{\text{"Wilson" pressure}}{\text{Final pressure}} = \pi_w$..	13.54	28.63	42·58	54.55
150 deg. F. superheat at stop-valve	U_s F.P.C.	—	23.48	59.07	81.37
	u'_w F.P.C.	—	20.17	47.71	63.58
	Equivalent reheat factor— $\dot{R} = \frac{U_s}{u'_w}$	—	1.1642	1.2381	1.2799
	Ratio $\frac{\text{"Wilson" pressure}}{\text{Final pressure}} = \pi_w$..	—	2.03	5.676	10.9
300 deg. superheat at stop-valve	U_s F.P.C.	—	—	4.75	37.05
	u'_w F.P.C.	—	—	4.30	30.89
	Equivalent reheat factor— $\dot{R} = \frac{U_s}{u'_w}$	—	—	1.105	1.1994
	Ratio $\frac{\text{"Wilson" pressure}}{\text{Final pressure}} = \pi_w$..	—	—	1.14	2.89

By the methods already explained we can calculate the superheat corrections corresponding to these values of $\dot{R}$. Thus let us assume as our standard conditions that the steam is supplied at a stop-valve pressure of 195 lb. absolute and at 150 deg. F. superheat; that it is wire drawn through the valves down to 180 lb. absolute and then expanded through the turbine down to 1 lb. absolute.

From Table VII, page 162 *ante*, we note that under these conditions the cumulative heat-drop or effective thermodynamic head is as follows:—

Hydraulic efficiency η ..	0·5	0·6	0·7	0·8
Effective thermodynamic head .. .. F.P.C.	227·70	218·58	213·48	209·08

If there is no superheat the corresponding figures become:—

Hydraulic efficiency η ..	0·5	0·6	0·7	0·8
Effective thermodynamic head .. .. F.P.C.	197·24	195·02	192·15	189·16

Now obviously if a turbine giving an hydraulic efficiency of 0·7 under the standard conditions has to work with the same initial and terminal pressures but with no superheat, its hydraulic efficiency will be altered since the total effective thermodynamic head is reduced and the average ratio of blade speed to steam speed correspondingly increased.

From the curve in Fig. 7, page 189, we note that for an hydraulic efficiency of 0·7 the value of $\frac{K}{U}$ is 598

Assume, then, this to be the value when the turbine is working under standard conditions. If the superheat is cut off the value of $\frac{K}{U}$ will be increased as a first approximation to:

$$\frac{598\ U_{150\ deg.}}{U_0} = \frac{598 \times 213.48}{192.15} = 665$$

From the efficiency curve it will be seen that this value of $\frac{K}{U}$ corresponds to an efficiency of 0·721.

Such a change in the efficiency will, however, alter the cumulative heat-drop to something between its value for $\eta = 0{\cdot}7$ and $\eta = 0{\cdot}8$. By plotting down the figures tabulated above it will be found that with $\eta = 0{\cdot}721$ the cumulative heat-drop (no superheat) becomes 191·53. With this value of U_0 we get another value of $\frac{K}{U_0}$, viz., 666. The corresponding efficiency is thus not appreciably altered and may be taken as 0·721. The useful work done is then $0{\cdot}721 \times 191{\cdot}53 = 138{\cdot}10$ ft.-lb. Centigrade units. Under standard conditions the effective thermodynamic head was 213·48 ft.lb. Centigrade units and the useful work done $0{\cdot}7 \times 213{\cdot}48 =$ 149·42 ft.-lb. Centigrade units. The relative consumption with no superheat should therefore be $\frac{149{\cdot}42}{138{\cdot}10} = 1{\cdot}0820$ times as much as with 150 deg. superheat. Proceeding in this way we get the following relative consumptions for different hydraulic efficiencies:—

Hydraulic efficiency ..	0·5	0·6	0·7	0·8
No superheat	1·0923	1·0798	1·0820	1·0913
150 deg. superheat ..	1·0	1·0	1·0	1·0
300 deg. superheat ..	0·8987	0·8979	0·9108	0·9130

According to the "Beama" corrections quoted

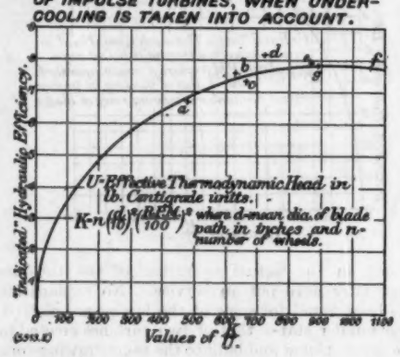

"Indicated" Hydraulic Efficiency.
U=Effective Thermodynamic Head in lb. Centigrade units.
K=n(d/12)²(N/100)² where d=mean dia. of blade path in inches and n=number of wheels.
Values of U.
0 100 200 300 400 500 600 700 800 900 1000 1100
G.S.B.C.

Fig. 8. "Indicated" Hydraulic Efficiency of Impulse Turbines, when Undercooling is taken into Account.

on page 53 *ante* the relative consumption with no superheat should be 1·16 times as much as with 150 deg. superheat and 0·891 times as much with 300 deg. superheat, as with 150 deg. The discrepancy is therefore large, and the proposed values of the equivalent reheat factors are inadmissible. Suppose we repeat the calculation and comparison with the reheat factors appropriate to steam expanding without condensation, taking the values of R from the diagram on Plate I *ante*. These values of R are, of course, really too small since condensation is known to occur, whilst the values of $\dot{R}$ are, as has just been shown, much too large.

On the assumption of no condensation, and assuming the standard conditions of 150 deg. F. superheat at the stop valve, with a stop valve pressure of 195 absolute, an initial pressure of 180 absolute and an exhaust pressure of 1 lb. absolute, we get the following figures, the first line in each case being taken from Table VII:—

Hydraulic efficiency ..	0·5	0·6	0·7	0·8
Cumulative heat-drop down to Wilson line F.P.C.	—	195·07	154·41	127·71
Adiabatic heat-drop beyond Wilson line u'_w F.P.C.	—	20·17	47·74	63·58
Ratio of "Wilson" pressure to final pressure π_w	—	2·03	5·676	10·9
Reheat factor from chart, Plate I .. .. R	—	1·0320	1·0580	1·0510
Cumulative heat-drop beyond Wilson line R u'_w	—	20·81	50·47	66·82
Total effective thermodynamic head, U'_{150}	227·70	215·88	204·88	194·53

Similarly, for the same conditions, save that there is no superheat at the stop valve, we get:—

Hydraulic efficiency ..	0·5	0·6	0·7	0·8
Cumulative heat-drop down to Wilson line F.P.C.	106·16	77·08	61·12	50·93
Adiabatic heat-drop beyond Wilson line u'_w F.P.C.	68·72	85·74	94·13	99·17
Ratio of "Wilson" pressure to final pressure, π_w	13·54	28·63	42·58	54·55
Reheat factor from chart, Plate I, R	1·1495	1·1470	1·121	1·083
Cumulative heat-drop beyond Wilson line, R u'_w	78·99	98·35	105·52	107·40
Total effective thermodynamic head U'	185·15	175·43	166·64	158·33

With 300 deg. superheat at the stop valve we get:—

Hydraulic efficiency ..	0·5	0·6	0·7	0·8
Cumulative heat-drop down to Wilson line F.P.C.	—	—	235·71	196·60
Adiabatic heat-drop beyond Wilson line, u' F.P.C.	—	—	4·30	30·89
Ratio of "Wilson" pressure to final pressure, π'_w	—	—	1·14	2·89
Reheat factor from chart, Plate I, R	—	—	1·0044	1·024
Cumulative heat-drop beyond Wilson line, R π_w	—	—	4·31	31·63
Total cumulative heat-drop, F.P.C.	266·96	253·09	240·02	228·23

Just as before we can calculate the relative consumptions using the curve in Fig. 7, and correcting the heat-drop for the change in the efficiency which results in a departure from the standard conditions.

The relative consumptions calculated on this assumption, that the steam behaves throughout as if completely supersaturated, are as follows:—

Hydraulic efficiency ..	0·5	0·6	0·7	0·8
No superheat	1·151	1·1690	1·1851	1·2041
150 deg. F. superheat ..	1·0	1·0	1·0	1·0
300 deg. F. superheat ..	0·8987	0·8908	0·8864	0·8714

These figures are, it will be seen, much closer to the results actually observed in practice than the set previously obtained. Hence the true value of the equivalent reheat factor is somewhere between $\dot{R}$ and R, but much nearer the latter than the former. It may be observed that the value 0·8987 found in the last line under hydraulic efficiency 0·5 is necessarily correct, since with this efficiency the Wilson line is not crossed when the initial superheat is as much as 150 deg. F.

The equivalent reheat factors R_w plotted on Plate I *ante* have been calculated on the assumption that

$$R_w = 0.8\,R + 0.2\,\dot{R}$$

With this value of R_w the relative consumptions come out as follows:—

Hydraulic efficiency η ..	0·5	0·6	0·7	0·8
No superheat	1·138	1·146	1·156	1·179
150 deg. F. superheat ..	1·0	1·0	1·0	1·0
300 deg. F. superheat ..	0·898	0·892	0·890	0·881

These relative consumptions come out therefore in good accord with Mr. Baumann's figure of 1·16 to 1 as the ratio of the consumption with no superheat to the consumption with 150 deg. F. superheat with modern turbines, and with the figure of 0·891 to 1 when a turbine designed for 150 deg. F. superheat is supplied with steam at 300 deg. F. superheat. Also the value of 1·146 for $\eta = 0{\cdot}6$ agrees quite well with the correction given in his original curve published when efficiencies were much lower than those now realised.

The points plotted in Fig. 7, page 189, have been calculated, making use of this value of R_w, and they seem to fit in satisfactorily. Further, it was noted with reference to Fig. 4, page 107 *ante*, that the point *f* related to an impulse turbine in which the ratio of blade speed to steam speed was greater than $\frac{1}{2}$. The curve, however, indicates no loss of efficiency due to this excess over the most economical ratio of blade speed to steam speed. This cannot be right since the efficiency of turbines falls off more rapidly with over-speeding than with under-speeding and the discrepancy is really due to the fact that the pressure and superheat were very high, and that a large proportion of the total expansion was effected before the saturation line was reached. In the other cases represented on the diagram the superheats and pressures were lower. A considerable portion of the expansion was therefore effected within the "saturated field," and on the view put forward above the turbines concerned have (on the assumption that this expansion took place in conditions of thermal equilibrium) been debited with much heat energy which never really became available. They thus compare unfavourably with the test represented by *f*. If instead of assuming that in these turbines the steam expanded in conditions of thermal equilibrium, that is to say

with an equivalent reheat factor $\dot{R}$, we adopt the view that the expansion beyond the Wilson line was effected with the "equivalent" reheat factor R_w, we get the efficiency curve plotted in Fig. 8, where it will be seen that the over-speeding of f has been accompanied by a distinct fall in the hydraulic efficiency. The writer has reason to believe that the drop in efficiency is really greater than here represented, as it appears that the test figures have not been confirmed in service. The curve drawn through the plotted points is a portion of an ellipse. As shown in Fig. 4, page 107 *ante*, the efficiency curve based upon the hypothesis that the steam expands in thermal equilibrium is not elliptical in character.

(*To be continued.*)

ALUMINIUM (BAUXITE) DEPOSITS AND THE PRODUCTION OF ALUMINIUM.

(*Continued from page* 165.)

We have found it expedient to deal somewhat fully with the treatment of aluminate, because it is a fundamental question in connection with all aluminium production, for which reason several eminent chemists are devoting much attention to the problem.

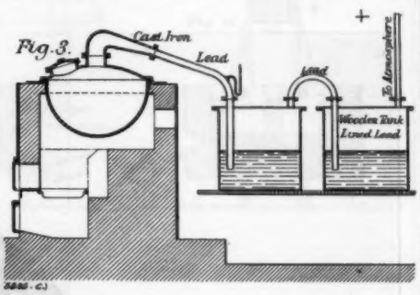
With reference to cryolite, in which the aluminate is dissolved, when undergoing electrolysis in the electric furnace to produce metallic aluminium, the natural cryolite is found at Ivigtut, in Greenland (also at Minsk, in the Ural), and has the chemical formula $AlF_3 . 3\,NaF$ or $Al_2F_6 . 6\,NaF$. Its principal impurities are quartz, iron pyrites, carbonate of iron and galena. It is cleaned mechanically by hand, and electro-magnetically. As supplied by the Oresund Chemical Works, Copenhagen, it contains some 50 per cent. fluorine, 12 per cent. to 13 per cent. alumina, but only $\frac{1}{4}$ per cent. to $\frac{1}{2}$ per cent. silicic acid and $\frac{1}{10}$ per cent. iron. Cryolite melts at about 1,000 deg. C.; at a red heat it loses up to 1 per cent. of water. At white heat sodium and the fluoride of aluminium volatilise, and alumina remains, in the shape of hexagonal flat pieces.

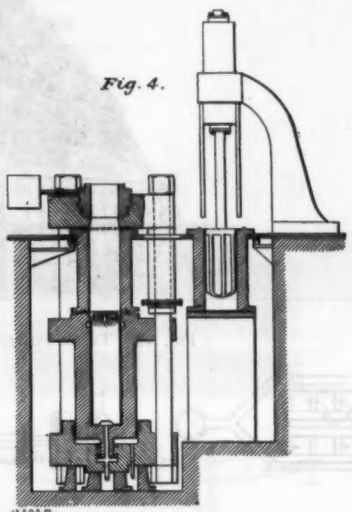
The artificial cryolite contains more fluorine, its chemical formula being $AlF_3 . 3\,NaF$ or $Al_2F_6 . 6\,NaF$; it is therefore better to use, but it also smokes more. It can be produced in different ways, but as a rule hydrofluoric acid has to be first manufactured. This is done by distillation of finely-ground fluorspar with concentrated sulphuric acid, the gas being collected in water. Our illustration, Fig. 3, shows the construction of the apparatus in question. Hydrofluoric acid causes ugly burns and attacks the mucous membrane, so the workman has to be very careful to grease himself and wear a gas mask. The hydrofluoric acid should not contain any silicic acid or any silicates, otherwise silicon tetrafluoride will be formed, which passes into colloidal silicic acid-hydrate, and this deteriorates the aluminium. The silicon, however, can be precipitated by means of fluorcalcium.

As the baths in the aluminium electric furnaces are constantly losing fluorine, fresh additions must be provided. If this were done by adding cryolite to the bath, the latter would by degrees become richer and richer in soda, and the aluminium would contain some sodium. Aluminium with but $\frac{1}{1000}$ per cent. sodium is bright, but if the contents rises to $\frac{1}{10}$ per cent. the aluminium becomes dull on the surface, and utensils made from it are apt to turn dark in colour. The addition, therefore, generally takes place in the form of aluminium fluoride, which is made from aluminium hydrate and hydrofluoric acid, or aluminium sulphate and cryolite. Natural fluoride of calcium, that is, fluorspar, is also used. The percentage of fluorine in the bath is ascertained at intervals by means of an Oettel apparatus.

Electrodes are an important item in the aluminium electrolytic baths or furnaces, inasmuch as there is about the same quantity of electrodes consumed, as the quantity of aluminium produced, and the electrodes, further, have to be nearly pure, as the proportion of ash should not exceed 1 per cent. In order to ensure economical and rational working, it is therefore necessary for any fair sized aluminium factory to have its own electrode factory. This also makes it possible to utilise the scrap ends of the electrodes, which amount to from 10 per cent. to 30 per cent. of the entire consumption. Good electrodes are a necessary condition for the satisfactory and remunerative production of aluminium, and we shall therefore also deal with this question at some little length.

Ordinary coke or coal cannot be used; even the purest anthracite gives electrodes with over 2 per cent. of ash, of which at least one-third is silicic acid. Natural graphite and coking coal are not pure enough either, and graphite, further, is somewhat expensive. For the purposes of electrolysis the current density ought to be 0·6 sq. cm. per ampere, or 0·9 sq. cm. to 1 sq. cm. per ampere, and even a lower current density is used. Retort carbon is used, but it generally contains some silicic acid, and it is therefore, preferably, used as an addition. Acheson's graphite is very pure, but in





any case is too expensive for use in Europe. Petroleum coke is therefore generally used. It is also expensive, but its percentage of ash only amounts to from 0·1 per cent. to 0·4 per cent., and rarely above 0·5 per cent. The American petroleum coke is generally purer. The Roumanian petroleum coke is made from distilled heavy crude oils, which are heated to a dark red heat, the petroleum coke remaining as a porous, partly hard, partly soft glistening substance, which is grainy or foliaceous in structure. This petroleum coke generally contains some 8 per cent. to 15 per cent. of volatile substances. The volatile constituents must first be driven out by red heat, in order to obtain good firm electrodes. The longer pieces of the coke are crushed to the size of nuts before being subjected to red heat. The heating furnaces, as constructed by Frantz Meisser, are about 6 m. by 5 m. and 6 m. high, with eight retorts of inside dimensions of about $\frac{1}{2}$ m. These retorts are filled from the top and emptied every 3 hours or 4 hours through water-cooled iron spouts below. The retorts are heated by means of producer gas.

After the heating process the coke is finely ground, generally together with the electrode remnants; in some places retort graphite is also added. If the pieces are too large they must first be crushed. The coke is next finely ground in a ball mill, and then mixed with about 20 per cent. of tar; some factories use less tar and one-third pitch. A little soot is supposed to make the electrodes firm, but the soot is often impure. If the tar contains water it must first be heated. Coal-tar pitch, obtained from coal distillation, which at most contains 1 per cent. to 2 per cent. of ash, is used. Blast-furnace pitch, which contains 20 per cent. of ash, is useless for the purpose. The ground material is mixed in kneading machines heated with steam. The substance, after a preliminary moulding, goes to the electrode press, in which it is exposed to as much as 500 atmospheres pressure.

In the aluminium furnace several electrodes are grouped in parallel, and as many as 40 groups, in the same number of furnaces, are coupled in series. The size of the electrodes depends, apart from the number used, also on the strength of current with which the furnace is worked, 8,000 amperes to 10,000 amperes are now quite common, but there are also larger aluminium furnaces with as much as 15,000 amperes to 20,000 amperes. The section of the electrodes varies from 20 cm. by 20 cm. to 40 cm. by 40 cm.

The electrode press, as shown in the illustration, Fig. 4, annexed, is vertical, with a turntable and a preliminary press. The cylinder is first pressed full of material and is then placed between the piston and the mouthpiece. The outer piston is first forced up by hydraulic pressure, and then the inner piston presses the substance through the mouthpiece, and the electrodes are then cut to suitable lengths. Another method is used to press the short electrodes direct in a mould, and in this case the material does not pass through a mouthpiece.

When the electrodes have been pressed and moulded, they are baked in a kiln. They must be exposed to a temperature exceeding 1,400 deg. C., in which process they lose some 10 per cent. of their weight. The furnaces are heated with producer gas and the electrodes are protected by earthenware sagars packed with retort-carbon powder, or with petrol-coke powder, or electrode scrap. The large quantities of distillates from the furnace must be arrested before the gas reaches the chimney stack, or the smoke nuisance is serious.

Of furnaces for the above purpose, mention may be made of the Mendheim tunnel furnace, on the Bock system, where the electrodes are moved through a covered way towards the heated central portion of the furnace, the electrodes being placed on a series of trolleys which, by hydraulic pistons, are pushed through the furnace. The electrodes are preheated by the escaping gases and are cooled by the incoming air, which thereby is heated. In this furnace the electrodes are burnt at 1,350 deg. C., a temperature, by the way, sufficient for electrodes for aluminium furnaces with a bath working at only 1,000 deg. C. Jehl, by cross-partitions in the trolleys, has constructed a kind of chamber system with this furnace, of which our illustrations, Figs. 5, 6, 7, page 192, show the central portion, where the burning takes place. The tunnel on both sides of the furnace has the same section. The exit gases pass through the economiser on the one side and then heat the electrodes which are being introduced into the furnace. The air cools the electrodes after they have been burned and is further warmed by the economiser.

The furnace mostly in use is probably that of Franz Meisser; it consists, as shown in the illustration, Fig. 8, page 192, of 16 chambers on each side of a gas conduit. The chambers are generally about 2 m. long and 1·5 m. broad, or larger. Two chambers are out of operation for the removal of the finished electrodes and insertion of new ones, and are separated from the rest by shutters. Fresh air comes into the furnace from the neighbouring chamber and is heated in the next five chambers, the baked electrodes and the chambers being cooled down. In one or two of the next chambers the producer gas is burnt, the heat going to the following six chambers, and the escaping gases then leaving through the chimney.

The same process takes place in the other half of the furnace. As the electrodes are finished and new ones inserted, these chambers are coupled-in and the neighbouring chambers are emptied of the finished electrodes. The illustration, Fig. 8, which is simply a plan in outline, shows the

construction of the furnace with the gas conduit in the centre between the two series of chambers. The gas, through a double pipe, passes down and out through the fine openings, where it meets the preheated air and burns. The air has entered through a previous chamber, the pipe having been removed. In the chamber, in which the burnt gases pass out to the chimney, the pipe to the left is used. If the chamber has to be emptied, inspected and refilled, the insulated iron lid is lifted by means of a travelling crane, insulated partitions first having to be inserted in order to separate the chambers in question from the rest.

Fig. 5.

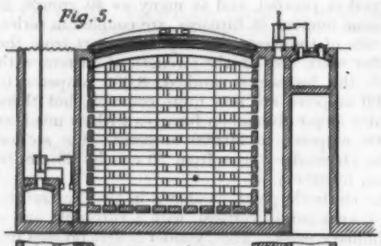


Fig. 6.

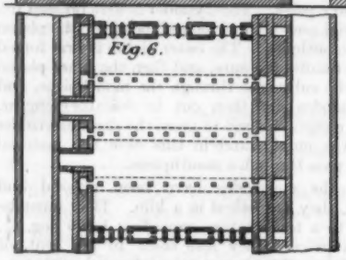
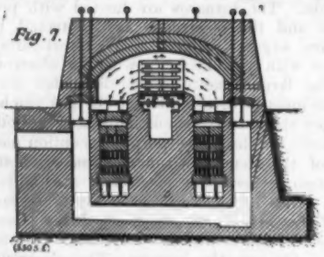


Fig. 7.



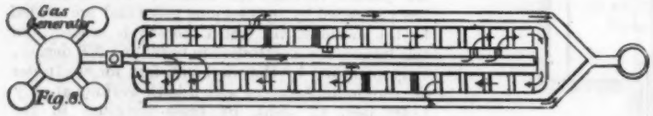
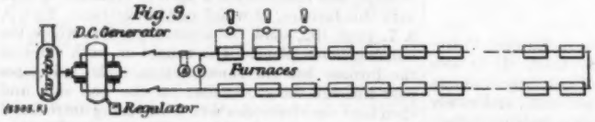


Fig. 8.

Fig. 9.



There is also a more recent Mendheim annular chamber furnace, where sagars or casettes are dispensed with, the chambers themselves forming the casettes; these are surrounded with a hollow brick wall, through which the gas passes. For the filling substance there is used fresh coke, which is piled high over and round the electrodes. The most interesting feature, however, about this furnace is this, that after it has been well started by a small gas producer, it will burn the distillate gases from the electrodes and the filling substance and use this heat for the furnace itself. This is stated to be more than sufficient to heat the furnace to the highest temperatures. There are 40 to 60 narrow cells in two rows, with one or more chambers, in which the fresh electrodes are placed, being filled up all round with fresh coke powder from portable receptacles, by means of a hose. The warm gas, or the air which is to be preheated, passes through the intermediate hollow brick wall. The distillates are led in the opposite direction to the exhaust gases, but through separate openings above the chambers, which openings can be covered. The removal of the burnt coke powder is effected by suction, which conveys the coke powder to the mixing place.

As regards the electrical installation for the electrolytic production of metallic aluminium from alumina, continuous current is required for the furnaces, each furnace requiring 6½ volts to 7½ volts; for starting purposes a regulating range of from 5½ volts to 8½ volts is needed. It is not desirable to construct the generators for such low voltages, and a number of furnaces, 30 to 40, are therefore coupled in series. The regulation is effected by resistances from 0 volt to the maximum voltage. If several generators are used they are run in parallel, and if there are several furnace series they are worked independently of each other. The location of the aluminium factory depends upon the situation of the available water power and certain transport considerations. If the energy has to be transmitted over some distance, it has to be transformed. The illustrations, Figs. 9, 10, 11, annexed, indicate the transformation from alternating to continuous current by means of rotary converters. In scheme 3, Fig. 11, the transformation is effected by a motor generator.

At the Chippis aluminium works, power from the Navisance and the Rhone is used, in addition to that to be transmitted from the Borgne, 17 km. distant. This will mean an aggregate of about 100,000 h.p. The concern belongs to the Aluminium Industrie Gesellschaft, Neuhausen. Some of the power is at present used for nitrate production. The illustration, Fig. 12, above, is that of the Tysse power station of the Hardanger Fiord, Norway, but the available space there is so limited, that it has been necessary to place the aluminium works some few hundred metres distant. The concern is owned by the Norwegian Nitride Company, which took over the works of the discontinued Hardanger iron and steel works, and where, at very short notice, a 30,000-h.p. aluminium factory has since been installed. This has already been in operation for a year or so.

The aluminium furnace (see Figs. 13 to 15, page 193), has the electrodes suspended from a cross bar. The furnace is tapped, or ladled, every third or fourth day, and moulds of 2 kg. to 40 kg. capacity are used. The cryolite melts at 1,000 deg. C., but if a little alumina is added, the melting temperature is reduced; with an addition of 5 per cent. of alumina the minimum melting temperature is reached, reminding one of the eutectic point of metallic alloys. With about 8 per cent. to 9 per cent. of alumina discontinuity seems to arise from the cryolite having altered its composition. If aluminium fluoride is added, the melting temperature falls still further. Aluminium fluoride also facilitates the solution of the aluminate, a point with reference to which Dr. Askenasy has published somewhat divergent results. With 20 per cent. to 30 per cent. of alumina the bath becomes more and more unstable, and there is a risk of the alumina precipitating undissolved, whereby the resistance is increased, irregular heating arises and the aluminium unites with the carbon to form a carbide, Al_4C_3. This aluminium carbide, which also occurs if the furnace be overheated, is yellow, and crystallises hexagonally; it is reduced very slowly to alumina and methane gas when treated with water at ordinary temperature. Moissan, therefore, has suggested that the escape of methane from the earth is due to aluminium carbide in its interior.

Temperature also plays an important part in electrode consumption, and if it be too high the air consumes the electrodes (see *b*, Fig. 16). Too short a distance between the electrodes also tends to increase their consumption (*d*). If the bath is too dead, the electrodes are apt to become pointed (*c*). If the contact of the contact bolt is inadequate, the electrode is consumed as in (*c*). A proper consumption of the electrode is illustrated in (*a*).

Temperature also plays an important part in the composition of the bath. With too high a temperature the fluorine will volatilise and must be replaced by the addition of more aluminium-fluoride. With too low a temperature an unduly hard crust is

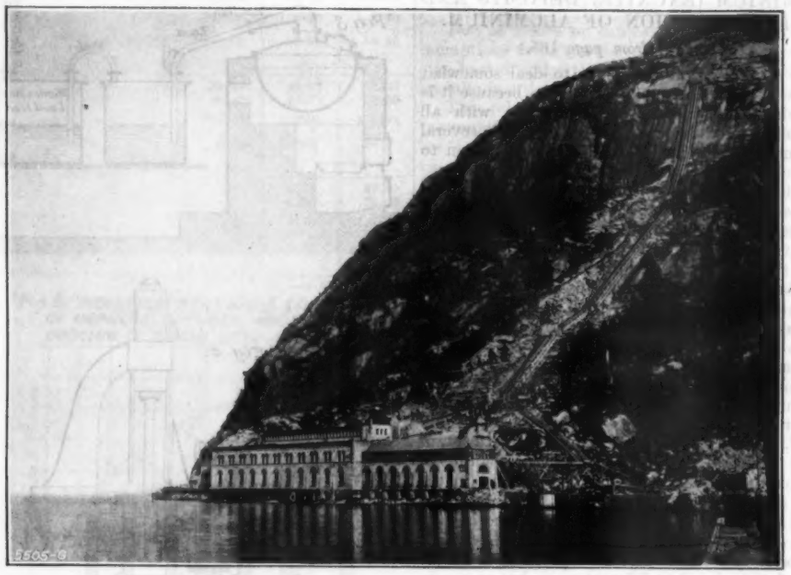


Fig. 12. Tysse Power Station, Hardanger Fiord.

Fig. 10.

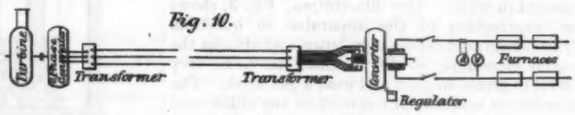
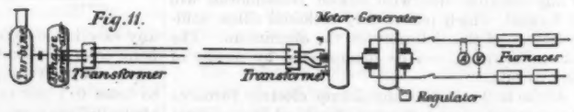


Fig. 11.



formed over the bath; besides, the aluminium which results at 625 deg., 650 deg. and 700 deg. C. is difficult to tap, and there is a risk of short-circuiting the furnace. When aluminium approaches the solid form, it becomes even lighter than the bath, it being only a little heavier than the bath in the melted state.

Under these conditions it is often necessary to switch off a furnace from the series. Sometimes a hole is burnt in the furnace, or the electrodes stick and cannot be adjusted. Then the bath takes too much current, so that the bar melts, and when matters get out of control, all the bars may in turn threaten to melt. The furnace is then short-circuited and a new reserve furnace coupled in, the electrodes are put right down into the bottom of the empty furnace, and the current in the series is reduced until the new furnace gets warm and the cryolite melts.

Temperature also plays a part as regards the combustion of the electrodes. With high temperatures, carbonic oxide is formed and burns with a blue flame; not unfrequently the flame may be yellow on account of the sodium. At ordinary temperatures between 800 deg. and 1,000 deg. C. carbonic acid, CO_2, is also produced direct. The volumetrical proportion in the waste gases varies from 5 to 10 up to 20 parts of carbonic oxide to 100,000 parts of carbonic acid.

The carbonic acid is formed by the electrolysing of the dissolved alumina; when all the alumina has been electrolysed, the electrolysis partly attacks the aluminium-fluoride. The fluorine will then form tetrafluoride with the anode carbon, a gas which is soluble in water without being decomposed; this gas is supposed to be harmless. The furnace attendant, in any case, will immediately notice when the alumina has been electrolysed, inasmuch as the furnace voltage then rises from its normal 7 volts to 15 volts, 17 volts, or even 20 volts, a pilot lamp will then glow, and fresh aluminate must be added.

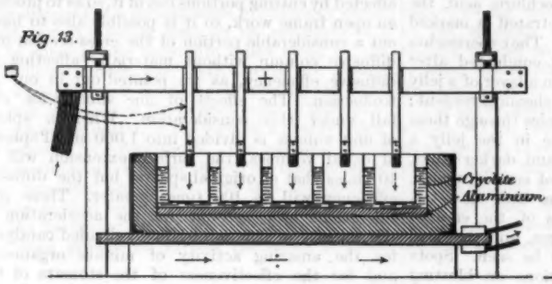
It has never been possible to detect hydrofluoric acid in the gases which leave the aluminium furnaces. It has been surmised that it is hydrofluoric acid which makes the window panes of the building dull, but as the bath or the electrodes contain some silicon, $\frac{1}{10}$ per cent. silicon-tetrafluoride has been found in the waste gases, which gas, owing to the moisture of the air, attacks the window panes. It also attacks any copper in the vicinity of the furnace and makes it black.

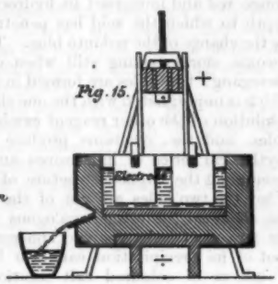
When a furnace gets heated considerably over 1,000 deg. C., a process takes place opposite to the one employed in the chemical production of aluminium. At higher temperatures the sodium-fluoride of the aluminium bath dissociates, the sodium ascends as small balls and burns with a vivid yellow flame. When the furnace gets too hot, the aluminium is also apt to dissolve the iron rakes which are used. A bath temperature of some 900 deg. to 950 deg. C. may be taken as the most suitable, although some recommend a lower temperature, 800 deg. to 900 deg. C., but the furnaces then require a good deal more looking after. One man can attend to some four or five furnaces.

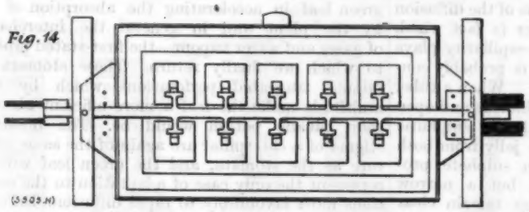
To complete our description we illustrate a furnace, Fig. 17, with negative electrodes inserted in the bottom, as is still the custom in some places. This construction is understood to apply to the Lambert furnace, Figs. 18 and 19, the bottom of which consists of electrodes inserted in a cast-iron frame. Also to the Hall furnace, Fig. 20, which, however, now only possesses historic interest.

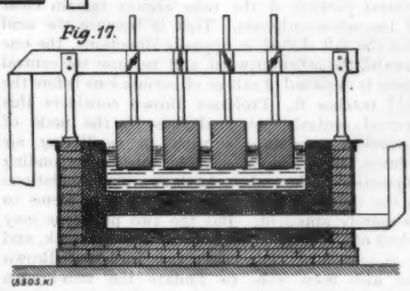
Aluminium well fills the moulds in which it is cast; near the melting temperature it becomes plastic and contracts as much as 1·8 per cent. lineally. If exposed to vibration between 550 deg. and 625 deg. C., it crumbles into powder, a peculiarity which comes in useful in the manufacture of aluminium paint, &c. Aluminium is generally remelted, prior to rolling or drawing; for this purpose the well-known Rousseu furnaces are used. Endeavours are being made to construct even larger melting furnaces with a capacity of several tons. The aluminium can be remelted without absorbing gases and without blistering; it is only covered with a slight oxide coating. Its purity should be at least 98 per cent., and for rolling purposes, 99 per cent.

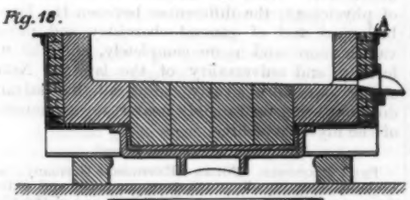
(To be continued.)

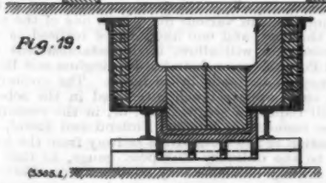


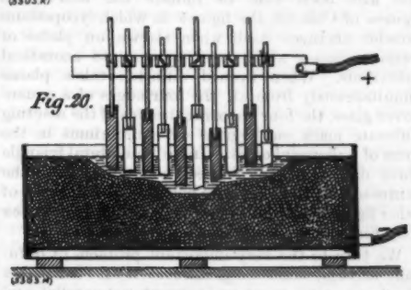












THE PRINCIPLES OF DIFFUSION AND THEIR ANALOGUES.

THE standpoint from which Professor Horace T. Brown, F.R.S., of London, first approached the Principles of Diffusion, their Analogies and Applications in a lecture, delivered before the Chemical Society in June last, was that of the physiological chemist. The outcome of the lecturer's many years of experimental and theoretical study of the phenomena of diffusion is, however, that the plant inhales the carbon dioxide of the air just as a solution of caustic potash absorbs this gas, that as regards diffusibility of gases and liquids physiological processes follow physical laws, that the diffusion and evaporation curves bear a striking resemblance to the diagrams illustrating the transmission of heat through thin lamina, equipotential shells surrounding electrically-charged bodies, magnetic and hydraulic stream lines, etc., and that all these problems admit of similar mathematical treatment. The statement may still surprise chemists as Nernst did in 1904, when he said that determinations of the velocities of reactions taking place at the boundaries of heterogeneous systems might entirely be vitiated if diffusivity were not taken into consideration as a limiting factor. Though a few of Professor Brown's analogies may look more apparent than real in their brief statement, his lecture was of the greatest interest, and it will probably be news to our readers *e.g.*, that the closing of a port by a perforated diaphragm will hardly impede the diffusion of gases through the ports, though the diaphragm may block 90 per cent. of the area of the cross section, leaving only 10 per cent. of open-perforation space.

The problem that confronted Professor Brown in his photosynthetic studies 20 years ago was the following. The animal inhales the oxygen of the air and exhales carbon dioxide into the air. The plant inhales the carbon dioxide and lives on it largely, building the manifold organic compounds up from the carbon of the CO_2. The inhalation takes place through the stomata of the green leaf, minute apertures in the cuticle of the leaf. Now the cuticle is impervious to CO_2—at any rate at the very low partial pressure of the 0·03 per cent. of CO_2 usually present in the atmosphere—and the stomata do not represent more than 3 per cent. of the leaf area at the best. Yet the leaf assimilates CO_2 at more than half the rate of a surface of concentrated caustic soda of the same area as the entire leaf. That means, that the minute apertures can drink in CO_2 at about 50 times the rate that the same apertures could do if they were filled with continuously-renewed caustic alkali. How is this possible?

The historical sketch of the development of the diffusion problem may also cause some surprise. The study of diffusion is generally coupled with the name of Thomas Graham. But though Graham experimented on diffusion through plugs of plaster or thin plates of graphite, and later in open jars, from 1826 till 1863 (he died in 1869) he hardly made

any quantitative determinations of diffusion coefficients, which Loschmidt first deduced from Graham's last experiments, and he did not attempt to formulate any general law as to the three variables: time, concentration, space traversed by the diffusate.

Incidentally Professor Brown remarked that, though Graham was Professor at University College and for some time president of the Chemical Society of London, English chemists did not take up this research which still receives but scanty treatment in text-books. Unknown to Graham, A. Fick, of Zürich, formulated the law of diffusion as early as 1855. Like Ohm's law, Fick's law was deduced from the principles enunciated in Fourier's Analytical Theory of Heat which Kelvin described as a great mathematical poem. If the two parallel surfaces of a plane lamina of thickness x and area A be kept at temperatures θ_1 and θ_2, then the quantity of heat Q passing through the lamina in time t is $Q = k\ (\theta_1 - \theta_2)\ A\ t/x$, where k is a constant numerically equal to the quantity of heat which will flow through unit area and unit thickness in unit time, when there is unit difference of temperature. For a small dx, $Q = k\,A\,.\,dt\,.\,d\,\theta/dx$, where $d\,\theta/dx$ is the temperature gradient. Fick argued that diffusion, the transference of a solute in its solvent, should follow the same law as heat, as it did in the case of the flow of electricity, so that temperature, concentration of the solute and electric potential were analogous, and that for regular flow along a diffusion column of constant cross-section (cylindrical or prismatic) the concentration gradient corresponded to the temperature gradient. Thus the differential equation would hold: $d\,\rho/dt = k\,.\,d^2\,\rho/d\,x^2$, where ρ indicates density, and k represents the coefficient of diffusivity which, subject to certain limitations to be pointed out, is constant for any solute or solvent as long as the temperature remains constant. Hence, Fick stated, the transfer of water and salt between two elements of space with differently-concentrated solutions should be directly proportional to the difference of concentration and inversely proportional to the distance between the elements of space.

Fick's own experimental verification of his law did not go very far, but the law has since been verified by optical, chemical and electrical methods. The most satisfactory of these verifications is due to Weber, the collaborator of Gauss, who, in 1879, proved that measurement of the electromotive force between electrodes of zinc and copper immersed in solutions of their sulphates, can be utilised for exact determinations of the concentrations of these solutions at their boundary surface. Stefan proved the law in 1879 from Graham's last data. A complete theory of diffusion from the kinetic point of view is still extant. But the law of Fick or Fourier enables us to solve all diffusion problems with fair approximation. Slight deviations from it may be due to the fact that the k is not constant, but dependent upon the partial concentrations of the constituents in mixtures, though Professor Brown himself failed to obtain distinct evidence of this influence. Dissociation would also affect diffusion, a point to which Professor Brown merely alluded. It was for this reason, however, that Fick's law was often quoted in the early days of the electrolytic-dissociation controversy, whilst it is very rarely referred to now. The diffusive efficiency is expressed by $Q = k.\ At\ (\rho - \rho_1)/L$, where L is the length of the column. For a cylindrical or prismatic column or bar, the diffusive flow is analogous to thermal flow, apart from the heat emission from the surface, and analogous to the steady flow of electricity along a conductor, in which case the coefficient of diffusivity k corresponds to electric conductance, and the surfaces of equidensity correspond to equipotential surfaces. When the column is not of uniform cross-section, the stream lines of Hele-Shaw and the lines of force of Maxwell still provide the analogy. A single sphere, electrically charged, is surrounded by concentric shells of equal potential, and the relative nearness of these shells (or circles, in sections) indicates the density gradient of the charges at points situated on the shells. The lines are more crowded near the sphere than further away. When two such spheres of unequal diameters, charged to the same potential of the same sign, are near one another, a system of oval or lemniscatic lines surrounds the two spheres; the lines are more crowded (and more curved, of course) near the smaller sphere, and there is between the two spheres a point of equilibrium.

These phenomena can easily be illustrated by the aid of salt solutions, especially such as give coloured precipitates, and columns of jelly (agar or gelatin) confined in glass tubes. When the jelly containing a little barium chloride is immersed in an alkali chromate solution, the advancing precipitate of the barium chromate arranges itself in bands of decreasing colour intensity and increasing width. When the jelly is coloured with Congo red and immersed in hydrochloric acid, the depth to which the acid has penetrated is marked by the change of the red into blue. The experiments become more striking still when conducted after Liesegang; two holes are formed in a layer of a jelly which is impregnated with the one chemical reagent; a solution of the other reagent exudes through these holes, and the reactions produce in the jelly a rhythmical series of light zones and darker rings, resembling the banded structure of certain agates. When the two holes are not of the same diameter, the chemical diffusion analogous of the case of the two electrically-charged spheres, and the dead spot of no precipitation can also be seen. Spots of ink or of coloured salt solutions on blotting paper afford still simpler illustrations of the diffusion phenomena; in that case, however (a fact which Professor Brown did not mention), capillarity plays an important part, but capillarity is probably concerned in the jelly experiment also. When a tube, containing jelly and some barium chloride and open at both ends, is placed horizontally in sulphuric acid, so that the acid can enter the jelly from both ends, the precipitation of barium sulphate progresses equally from both ends, but a narrow central portion of the tube always remain clear of the white sulphate. That is because the acid and the salt diffuse in opposite directions, the one inward, the other outward, and because the central space is depleted of salt or of barium ions before the acid reaches it. Professor Brown considers this neutral central spot analogous to the node of acoustical experiments with an oscillating air column, the dead space in the tube corresponding in position to the node. As there are no oscillations in the diffusion experiment, the analogy seems to be merely apparent. But the two problems may admit of the same mathematical line of attack, and it is certainly interesting that Professor Brown has also been able to imitate the well-known figures of Chladni, the figures in which lycopodium powder arranges itself when strewn on plates of various shapes which are thrown into acoustical vibrations. When inward diffusion takes places simultaneously from all the four edges of a square cover-glass, the four opposing streams of the reacting diffusate mark out regions of equilibriums in the form of a diagonal cross. In an equilateral triangle three dark lines are formed, extending from the centre of the triangle to the corners; photographs of other figures, suggesting also the structure of complex soap films, were exhibited by Professor Brown.

We turn to the very important problem of diffusion through conical apertures. With such tubes the flow is convergent or divergent, not parallel, and the density gradient is not uniform, but greater in the narrow than in the wide portion. Suppose we have a truncated cone, 10 cm. in length (or height), the smaller end of which has an area of 1 sq. cm. at a distance of 1 cm. from the apex of the (complete) cone; then it can be shown that the diffusion flow through the cone should be eleven times greater than the flow through a cylindrical tube of the same length and of the uniform cross section of 1 sq. cm. As regards the mathematics of the phenomena, Professor Brown referred to Sir Joseph Larmor and Mr. R. A. Fisher, whose deductions have been confirmed experimentally.

It will be recognised that this accelerated flow through conical tubes has a bearing on the breathing of animals; for in the bronchial tubes the interchange of gases depends on diffusion, and the fact that there are a large number of bronchial tubes close to one another is another important factor. When a septum, perforated by many small holes, is interposed in a system of parallel stream lines, the the lines crowd when near and in the perforations and become parallel again further away. It is owing to this fact, Stefan pointed out in 1881, that evaporation from a liquid surface takes place in divergent hyperbolic lines, the foci of which lie in the bounding edges of the surface, and that the evaporation is therefore much more rapid near the edge than in the central portion, and further that the evaporation is proportional to the linear dimension of the surface and not, as was assumed, to its area. The experimental proof of this was only given by Professor Brown and Mr. E. Escombe. Further, just as the electric capacity of a plate is not much affected by cutting portions out of it, so as to produce an open frame work, so it is possible also to block out a considerable portion of the cross-section of a diffusive column without materially affecting its diffusive efficiency, as we pointed out in our introduction. The effects of fine subdivision also fall under this consideration. When a sphere of unit volume is divided into 1,000 small spheres of equal volumes, the surface extension will be 10 times that of original sphere, but the diffusive efficiency will be 100 times greater. These considerations may account for the acceleration of the velocity of reaction by finely-divided catalysts, for the amazing activity of minute organisms, and for the effectiveness of the stomata of the green leaf in accelerating the absorption of CO_2 by the plant and in general the interchanges of gases and water vapour—the first-stated problem to which we finally return. Those stomata are minute truncated perforations which by their multitude make the leaf a more efficient absorber than caustic potash would be. The breathing stigma of a caterpillar are again of the same structure as the stomata, and the green leaf will not represent the only case of adaptation to the conditions most favourably to rapid diffusion. Diffusion is by no means always so slow as it was in Graham's open-jar experiments, when he found that carbon dioxide can diffuse through air at the rate of 7·3 cm. per minute, while hydrogen travelled five times faster.

There are many other points of interest in Professor H. T. Brown's lecture—which was published in the July issue of the Journal of the Chemical Society—and a careful study of it will prove most instructive. With the advance of our knowledge of physiology, the differences between the laws of biological and of general chemistry and physics vanish more and more completely, and the uniformity and universality of the laws of Nature stands out more clearly. But all that advance does not bring us tangibly nearer any explanation of the mystery of life.

The Proposed Polar Express.—Germany and Finland seem equally anxious to increase and extend their connections in various directions, one of the plans towards this end, and one likely to be realised as soon as circumstances will allow, is the establishment of a so-called Polar Express, between Helsingfors and Berlin, the journey to be made in 30 hours. The authorities on both sides appear much interested in the scheme, which will require a steam ferry, or, in the meantime, a steamer connection between Finland and Reval, and the alteration of the Reval-Riga railway from the broad Russian to the ordinary European gauge, so that the German railway carriages may go direct from Berlin to Helsingfors, where, as matters stand at present goods would have to be reloaded for transit further north.

Eucalyptus Oil Production in New South Wales.—Considering the great variety of the Australian eucalyptus trees, it is not astonishing that there are many kinds of eucalyptus oils which already find varied applications, but which certainly could be more fully utilised. In 1917, Australia exported to the United States, 4,829*l.* and to Canada, 1,224*l.* worth of such oils, the respective figures for 1916 being 2,434*l.* and 140*l.*, and the production and trade in the oil could largely be increased, no doubt. The actual chief uses of the oils are for medicinal purposes, for perfumery and flavouring, and for ore flotation; large bulks of oil are wanted for flotation. It is said that of the 300 species of eucalyptus, not more than 15 can be utilised for their oils; but that estimate may be too low. So far, the oils of 160 eucalyptus have been examined for their products. The leaf oil of eucalyptus macarthuri, a tree of very rapid growth, contains 60 per cent. of geraniol and of geranyl acetate, valuable in the preparation of perfumes; eucalyptus citriodora and staigeriana yield substitutes for lemon oil, only in small percentages, but yet in industrially-paying quantities. Eucalyptus trees prosper also in other countries, into which they have been introduced, notably in swampy districts, and the oil industry is, therefore, not of interest to Australia alone.

TEMPLETS, JIGS AND FIXTURES.
No. XI.

By JOSEPH HORNER.

THE illustrations in this article show fixtures holding gears to be cut on the gear shaper by the Fellows' Gear Shaper Company, of Springfield, Vermont, U.S.A. Some observations respecting the methods of cutting adopted in this unique machine should preface the account of the fixtures.

The central fact in the Fellows system is that the cutter is generated—not copied from any pre-existing shape, but produced on the basis principle of the involute tooth. A rack with straight tooth flanks disposed at a certain angle of obliquity would mould correct involute teeth on the periphery of a disc of some plastic substance rolled along it. In the Fellows' cutter, the tooth curves are ground with a plane face of a wheel representing the flank of a rack tooth set at the correct angle of obliquity, past which the cutter, in the form of a gear is rolled, and indexed for every tooth. The essential points in its manufacture are that the curves thus obtained being generated are correct, and that the grinding is accomplished subsequently to the roughing-out and the hardening of the blanks. After the teeth have been ground no further hardening is done, and distortion is impossible. The cutting ends are ground with 5 deg. of top rake.

The cutters used for producing helical teeth on the Fellows' machines generate these by a positive—a direct motion imparted to the cutter spindle, instead of using change gears to obtain the angle of helix. A helical guide gives the twisting motion to the cutter spindle, as it is reciprocated up and down on the cutting and return strokes. The guide is a solid block of cast-iron generated to a helix angle of the correct lead, being an exact continuation of the helix angle of the cutter teeth. The guide with which it mates is seated in an enlarged hub that forms a portion of the upper index wheel. For helical gears the firm adopts the stub form of tooth which they introduced several years ago. It has 20 deg. of pressure angle, and a shorter addendum and dedendum than the Brown and Sharpe standard.

The cutters used are essentially gears of narrow face, differing therefrom only in the front rake imparted at the cutting ends of the teeth, and in the clearances of the flanks. One cutter will generate all gears of the same pitch with any numbers of teeth. They are made in two sizes only, one of 4 in. pitch diameter for all gears of 6 pitch and coarser, and one of 3 in. pitch diameter for gears of 7 pitch and finer. As the number of teeth in a cutter varies with the pitch, this fact is made use of to simplify the setting up of the change gears on the machine. It is convenient to use a "pitch gear" on the intermediate stud, having just twice the number of teeth that there are in the cutter. These are furnished for all standard gears. The exceptions are, that with gears of more than 51 teeth, the pitch gear has the same number of teeth as the cutter, with those of less than 16 teeth, it has four times the number. In each case it introduces a fixed ratio into the train.

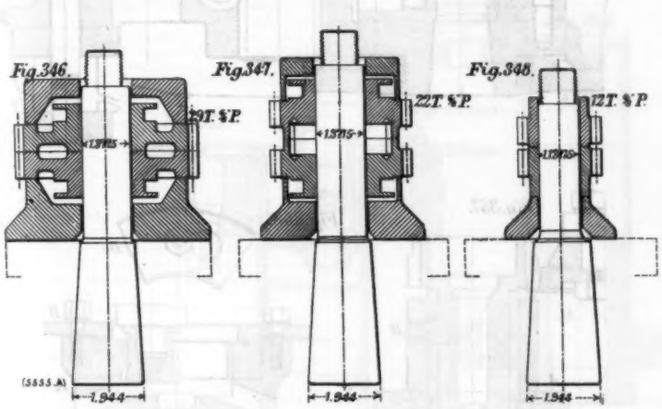
It is usual to divide the work between a roughing and a finishing cut. The more nearly accurate teeth are required the more desirable is this division. The first removes the bulk of the material, the second finishes finely. It is necessary that the roughing should be done with accuracy, for otherwise unequal amounts will have to be removed by the finishing cutter, and this will result in some residual errors which may have to be corrected with a third cut. For this reason, the Fellows' Company recommend using one set of machines for roughing and another for finishing, and to employ machines of the same kind for both—a gear shaper rather than one using milling cutters. Special roughing cutters are made with the top face ground to a rake of 10 deg. instead of the 5 deg. that is imparted to the finishing cutters, and having also teeth slightly thinner on the pitch line. This is preferable to using the finishing cutter for roughing, since it does not work so rapidly.

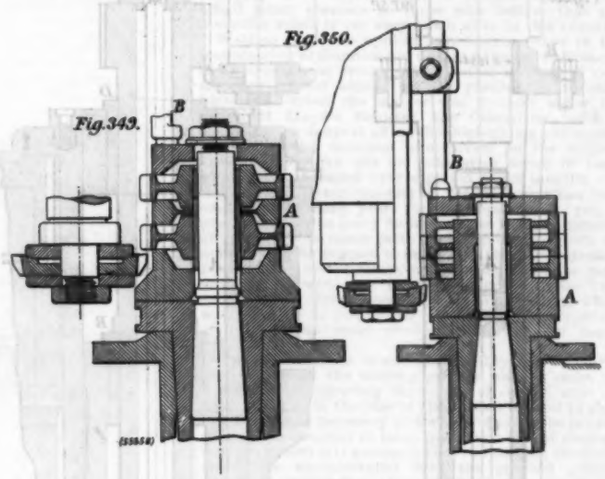
The cutter usually operates on a "pull" or draw-stroke. This, which acts through the arbor and work spindle, is recommended rather than the push stroke when conditions permit its employment. A work support is set above in the line of action of the drawstroke. But as this cannot be used in many cases of shouldered and internal gears, then the work is supported on some kind of face plate or fixture, always designed to support the gear close to the roots of the teeth, being itself supported on the flanged face of the work spindle of the machine. The variations in the forms of fixtures are extremely diverse to suit every class of gear, external and internal, with bores, or with solid bosses, or plain annular rings, or to be cut singly or in series.

The degree of accuracy with which the cutter works depends very much upon the care exercised in making and mounting these fixtures. The arbors and bushings must be central and concentric; fixtures, faceplates, and washers be truly faced. All arbors should be casehardened and ground, or hardened and ground. Bushings and washers should be ground. The running truth of arbors in their holes is tested with a dial indicator. The maximum amount of eccentricity permissible is 0·0025 in., and even this is undesirable. A particle of dust or dirt on the arbor will throw it out by this amount. Again, the gear blank, when mounted on the arbor, is tested similarly with an indicator before the teeth are cut, and if found eccentric, it must be corrected if the best results are to be secured. The illustrations which accompany this article give some idea of the many-sided character which these fixtures assume. And one observes, too, how great has been the influence of the automobile industry in multiplying the designs of fixtures.

In most of these examples, the face plate mounted on the broad flange of the work spindle is an important element, used sometimes in conjunction with the reverse cone of the arbor, and sometimes without that. A method commonly adopted is to use an arbor, this being either one of the standard sizes supplied with the machines, or one made specially to suit a bore. The blanks are carried on this with their rims supported on the face plate, which is made as large as will just allow the cutter to clear the periphery of the plate. The blank is clamped down with a nut direct on the plate. Or a top plate is used, on the outside of which the nut is tightened. The latter is most desirable when a draw-cut is employed. Then the work support takes a bearing above the top plate. This general method occurs in numerous variations.

Fig. 346 shows a convenient method of holding automobile transmission clutch gears. The gears, centred by their bores fitting directly on the arbor, are gripped between two face plates, which are case hardened, a lower and an upper one shaped and machined to clear the projecting bosses on the gears. The blanks are thus supported close to the rim in opposition to the stress of cutting, only just sufficient space being left behind the roots of the teeth to permit the cutter to clear the face plates. The tightening is effected with a nut screwed on the upper end of the arbor pulling against the reverse taper of the latter seated in the work spindle. This is a feature in the Fellows' machine which avoids clamping on the arbor itself, since it takes place on the splndle flange to which fixtures of the face plate design can be attached, as shown in this and other illustrations. The tighter the work is clamped, the more securely is the tapered arbor held in its spindle. Fig. 347 illustrates two clutch gears of a different shape and size, for which the sectional forms of the clamping plates are suitably modified. Fig. 348 shows two small pinions being held between a lower face plate, and a nut screwed on top of the arbor, contact of the pinions being made against their opposed boss faces.





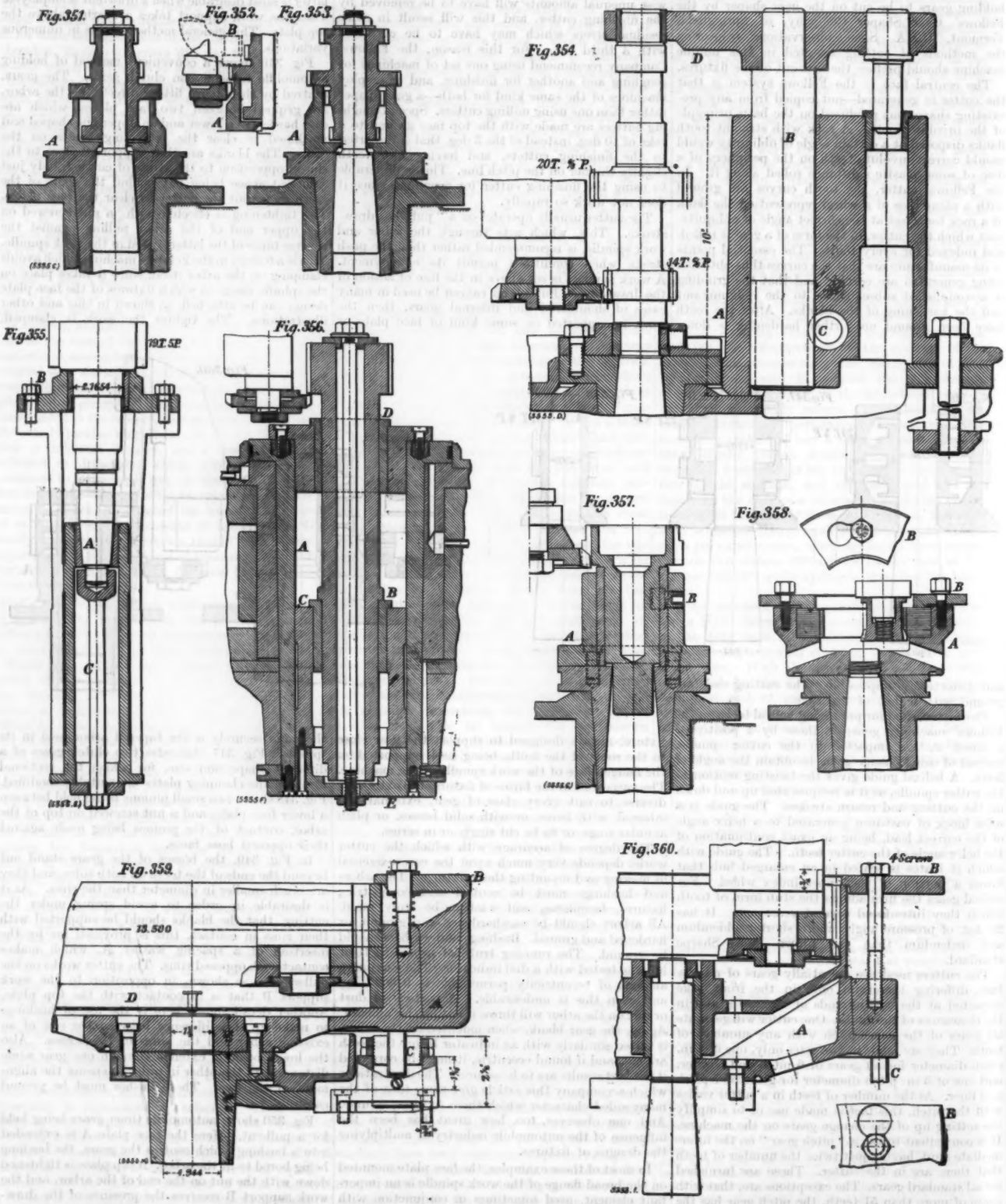
In Fig. 349, the bosses of the gears stand out beyond the ends of the teeth on both sides, and they are much smaller in diameter than the rims. As it is desirable in order to avoid spring under the cutting, that the blanks should be supported with their rims in contact, this is provided for by the insertion of a spacing washer A, which makes contact with opposed rims. The cutter works on the pull-stroke, as shown, in opposition to the work support B that is in contact with the top plate. Another detail shown here is the use of bushings to make up the difference between the size of an existing arbor and the bores of the bosses. Also the lower bushing extends through one gear some distance into the other in order to ensure the alignment of the two. These bushes must be ground carefully.

Fig. 350 shows automobile timer gears being held for a pull-cut. Here the face plate A is extended into a bushing which centres the gears, the bushing being bored to fit the arbor. A top plate is tightened down with the nut on the end of the arbor, and the work support B receives the pressure of the draw-cut.

Figs. 351 to 353, on page 196, show the mountings of an automobile countershaft cluster gear with a three-speed forward, and a reverse comprised in one piece. This cluster gear is of that design

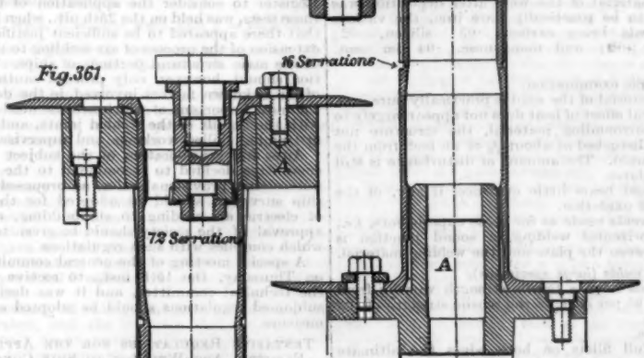
in which the gear has a hole to revolve on a shaft, instead of being, as in the next example, made solid. The hole is, therefore, as in previous examples, made the means of setting, and also of rotation during cutting. Three settings are necessary here, shown in the three successive drawings. In the first, Fig. 351, the largest gear blank is supported on the rim of a hollow face plate A, while the two smaller gears are being cut. The blanks, centred by the hole directly on the arbor, are bolted down in opposition to the taper of the arbor with the nut and washer seen. The cutter for the two small gears operates on the push-stroke. A second fixture, Fig. 352, similar to the first is used during the cutting of the largest gear, but this cutter acts on the pull-stroke, the work support B being set in opposition to it. In the final setting, Fig. 353, the fourth gear is cut on a push-stroke. The fixture A is similar to the others, but is deeper to receive the two small gears that were first cut. The method of holding is the same.

Fig. 354 illustrates a fixture used for cutting the teeth in automobile countershaft gears of another type. This fixture provides a special support for the gear shaft at the top end, the machine arbor not being used in this case since the blank has no hole through it. It consists of a main casting A, which



also fulfils the function of a chip pan at its lower end that completely surrounds and fits closely to the flange of the work spindle. The vertical stem B is provided with circular rack teeth, and the pinion C meshing with these lifts the top support D in order to permit of the removal of the work. At the lower end, the gear blank is supported by means of a hardened and ground bushing on the floating fixture —floating because it is left loose until the blank has been tested with an indicator, when being found correct the fixture is tightened with screws. The work is clamped in the fixture with the headless screw pressing against the brass shoe seen.

Fig. 355 is a direct-drive pinion for automobile transmission. Support is afforded to its long boss in a bush A below, in addition to that given to the top end next the pinion, which alone would be insufficient to get a satisfactory grip of so long a boss. The top bushing, hardened and ground, is inserted in the face plate B, which is free to float during testing, being afterwards secured with screws, and is clamped by means of the through-bolt C. The bolt passes down to the lower end of the machine spindle, where it is provided with a washer split for rapid removal and insertion without withdrawing the bolt.



Another method of fixing a pinion with a long boss is shown in Fig. 356. A feature of this mounting is that a machine having a standard work spindle could not be used, but, instead, there is one shown of larger size on a machine made specially for carrying gears with long shanks. The work spindle A has a hole 5⅞ in. in diameter, which entails some modifications in the design of the apron. The pinion here is not supported in a floating fixture, but is located by means of two bushings that fit the journals on which it will run when in service. The long boss extends to the lower end of the work spindle, where it is supported and centred with a shouldered bushing B, that fits a second bush C, which fits in the bore of the work spindle. The top bush is split in two pieces to facilitate loading the blanks. The lower outside bush C is attached with screws to a clamping plate E that is screwed to the lower end of the work spindle. A central bolt passes through this plate, pinion and boss, and is the means of securing the pinion, the clamping taking place between a washer at the lower end and a nut and collar at the top. As there is sufficient clearance for the cutter at the lower face of the pinion, and as the work is rigidly held down, the pull-stroke is employed without risk of the pinion being drawn away from its seating.

An automobile drive-shaft pinion with a much shorter boss than that in Figs. 355 or 356, is seen in Fig. 357. This is mounted on a floating fixture, but the shank being shorter, does not need the lower steadying bush in the work-spindle, nor the pull bolt of those designs. The fixture is a deep boss A screwed to the flange of the work spindle to receive the boss of the pinion in an intermediate bushing, hardened and ground, on the upper end of which the lower end of the pinion rests. The pinion is secured with a grub screw B pressing against a segmental shoe of brass. After it has been placed in the fixture, it is tested with a dial indicator, and when found true, is clamped. The cutter is used on the push-stroke because the space at the lower end of the pinion is insufficient to allow it to clear, and also because if the draw-cut were adopted, it would have a tendency to pull the pinion out of the fixture, as no pull bolt is present.

Fig. 358 illustrates what is termed a "pot type" of fixture, A, holding a pile of plate clutch discs during the cutting of teeth on the interior faces. It is screwed to a special short work arbor, with an ample base that lies on the flange of the work spindle. The discs are clamped down with a ring B provided with slot holes, as seen in the detail above, to facilitate the clamping and removal, the ring being turned sufficiently to allow the screw heads to clear the larger part of the slot. The diagonal channels, several of which are disposed round the fixture permit the escape of chips and oil.

Another pot type of fixture for supporting an internal gear is shown by Fig. 359, being one for a truck drive. In this case two rings are being supported in the fixture A, which fits on the top of a special work arbor, and is screwed directly down to the work spindle, and attached to the apron of the machine. Instead of using a circular ring for clamping as in the last example, four clamps B are employed, each with its screw, the clamps taking a bearing on the rim of the fixture and the internal gears. The clamps have slot holes, so that they are not lifted off for the insertion and removal of work, but are simply drawn back when the screws are loosened. A spring is located beneath each clamp to assist in starting it when the bolt is slackened. The rim almost directly beneath the location where the cutting is done is supported by means of a roller C carried in the apron. Its precise height is adjusted and set with lock nuts. A chip pan forms a portion of the fixture, provided with a strainer D to separate the chips from the oil. This is removed each time a gear blank is taken away, and cleaned out. The oil passing through the holes, returns to the circulating pump.

The illustration, Fig. 360, is that of a special fixture A, made to hold an internal gear for a tractor. It is clamped directly to the top of the work-spindle with screws, and the gear is located within it by the work-arbor. As its bore is considerably larger than the diameter of the largest arbor which the machine will carry, the difference is made up with the bushing shown. This is clamped on the arbor by means of the nut above. The diameter of the fixture is sufficient to support the rim of the gear, which is clamped down with four screws passing through a circular plate B, the internal diameter of which leaves enough clearance for the cutter to pass by. It operates with a push-cut. A roller support C is disposed in opposition to it as in the previous example. The circular clamping plate B has the same form of slot holes for the screws as that shown in Fig. 358.

Figs. 361, 362 show fixtures specially adapted for the handling of aeroplane hubs. That shown by Fig. 361 holds the hub in position, while the serrations are being cut in the hole. In Fig. 362, the work is reversed for cutting the serrations on the external diameter. The floating fixture A in Fig. 361 permits the hub to be inserted directly into the work-spindle, a special one being made. A bushing which is hardened and ground locates the hub accurately, and this is held in the floating fixture which is clamped to the top face of the work-spindle. The fixture A in Fig. 362 is made to fit directly on the work-spindle, and, therefore, has no floating movement. It also fits the internal diameter of the hub at the locality where the serrations have been already cut. The work is clamped to the fixture directly by means of screws, as illustrated. A push-cut is employed in each case.

APPLICATION OF ELECTRIC WELDING TO SHIPBUILDING.

WHEN the history of the development of engineering during the war comes to be written, the chapters on the progressive improvement of electric welding will afford much pleasure to those who believe that the inventive spirit is yet very much alive in this country.

Welding has been applied in countless ways to the manufacture of munitions of war, and the more advanced shipbuilders soon recognised that this method of construction offered almost endless possibilities to shipbuilding. When the matter was brought under the notice of Lloyd's Register, the Committee, with a characteristic desire to afford the shipbuilding community the very latest technical information on the subject, arranged to carry out an exhaustive series of tests, which have extended over a period of six months.

Although electric welding in various forms has been employed for many years for ship repair work, yet, in practice, owing to many factors, its use has been practically confined to those parts of the structure which are not likely to be exposed to important structural stresses. It is only in recent times, commencing from the early days of the war, that appreciable progress has been made in the developments of electric welding which would appear to justify the extension of such methods to replace the usual riveted connections of heavy structural work.

The aim has been to secure reliability and regularity of operation in the welding process, and to assist the workmen by improving the means of control over the work. Just as in the case of application of steel to shipbuilding it was necessary to devise means for the production of the material in large quantities and of constant quality, so also is it necessary that the welding electrodes should be manufactured with the greatest possible degree of uniformity. Reliability of operation is also facilitated by adjusting the density of the electric current to the size of electrode used, and further, the size of the electrode should reasonably vary directly with the thickness of material to be connected.

Research was necessary to discover means for minimising the burning of the deposited material in the direction of preventing oxidation. In the early days of welding, the molten electrode was exposed to air throughout the whole time of deposition and, consequently, oxidation was more or less certain to occur. With coated metal electrodes, burning is reduced to a minimum by the use of a slag which envelops the molten steel and floats on its surface after contact is obtained with the material to be connected. Even in this system skilled workmanship is essential, as the production of a long arc obviously increases the chances of burning.

The composition of the material of the electrode in relation to the nature of the steel to be connected is obviously a matter of importance. What the composition is to be can only be gauged by experiment and by wide experience, and it is in devising the physical tests for work of this nature that the greatest difficulties arise.

It is commonly accepted that the tests imposed on manufactured material do not in any way represent the strains which may be experienced in practice. Such tests are rather based on simple means for determining the average reliability of the material. Thus also in this case no one particular test is likely to determine whether the welding process under trial is sufficient for the work it is likely to have to do. It is, therefore, necessary to approach the problem rather on the basis of circumstantial evidence, and to decide from a number of different types of experiments whether, on the whole, the performance is satisfactory.

The more particular problem in shipbuilding is the connection of mild steel containing a percentage of carbon of about ·15. This material in the form of plates and section bars has considerable work done to it during the process of manufacture, with the consequence that it possesses a fine structure and a ductility which is uniform in every direction. The finished material may be said to be practically free from fibrous structure.

With electric welding, molten metal is attached to the mild steel and from the extent of the cooling surface the deposited material is rapidly lowered in temperature with the consequence that the weld tends to become deficient in ductility. The problem therefore is to select

the material of the electrode so that the general elastic properties of the structure are not unduly depreciated.

The investigations were undertaken to determine the possibilities of the application of electric welding to shipbuilding, and as it was desired to obtain as good a knowledge as possible of the physical properties of the combination of rolled and welded material highly skilled operators were employed.

It must, therefore, be realised that the results of the experiments which have been made represent skilled practice, and that in general such performance can only be equalled with good workmanship and efficient supervision.

NATURE AND DESCRIPTION OF EXPERIMENTS.

The general scope of the experiments included :—

(*a*) Determination of modulus of elasticity and approximate elastic limit.
(*b*) Determination of ultimate strength and ultimate elongation.
(*c*) Application of alternating stresses with—
(1) rotating specimens,
(2) stationary test pieces.
(*d*) Minor tests, such as—
(1) cold bending of welds,
(2) impact tests of welded specimens.
(*e*) Chemical and microscopic analysis.

Tests were carried out on specimens as large as possible, particularly in respect of the static determinations of elasticity, ultimate strength and elongation, some of the test specimens being designed for a total load of just under 300 tons. The advantage of these large specimens was that the effect of workmanship was better averaged and the results were more comparable to the actual work likely to be met with in ship construction.

With alternating stresses the specimens were relatively of small size. For the rotating test pieces, circular rods, mainly machined from a welded plate, were used, the diameters selected being 1 in. and ¾ in. These bars, about 3 ft. in length, were attached to a lathe headstock and a pure bending moment in one place was applied by means of two ball races to which known weights were attached. The material of the bar was thus exposed alternately to maximum tension and to equal maximum compression once in each revolution. The machine was run at about 1,060 r.p.m. Bars of identical material were tried in pairs, one specimen welded and the other unwelded, and the number of revs. before the specimens parted was observed for various ranges of stresses varying from ± 15 tons to ± 6 tons.

In the second series of alternating stress experiments flat plates were used of three thicknesses, viz. :—½ in., ¾ in. and 1 in. These specimens were tried in groups of 4, each group consisting of 1 plain, 1 butt welded, 1 lap welded, and 1 lap riveted plate. The specimens, which were about 14 in. long by 5 in. broad, were clamped along the short edges, so that the distance between the fixed lines was 12 in. Each plate was also clamped, near the middle, to the end of a pillar, which by means of a crank arm was caused to oscillate and to bend the specimen equally up and down by adjustable amounts (the maximum total movement in any of the experiments tried was ⅛ in.). The machine was run at various revs. (not exceeding 90 per minute) and the number of repetitions at which the specimen parted was observed.

Minor tests of various kinds were undertaken, of which the principal had reference to the suitability of the welded material to withstand such bending and shock stresses as might occur in the shipbuilding yards. The experiments on bending consisted of doubling the welded plate over a circular block of diameter equal to three times the plate thickness, and comparing the results with those of the plate of the same material, but unwelded.

In the impact tests heavy weights were dropped from various heights on to the welded portion of a plate 5 ft. in length and 2 ft. 6 in. in breadth, the weld being across the plate parallel to the shorter edge. The deflections were noted and the condition of the weld was examined after each blow.

The chemical and micrographical examination followed the ordinary practice.

SUMMARY OF EXPERIMENTAL RESULTS.

1. *Modulus of elasticity and approximate elastic limit.*
(*a*) In a welded plate the extensions in the region of the weld are sensibly the same as for more distant portions of the unwelded plate.
(*b*) With small welded specimens containing an appreciable proportion of welded material in the cross-sectional area, the relation between extension and stress is practically the same, up to the elastic limit, as for similar unwelded material.
(*c*) The elastic limit (or the limiting stress beyond which extension is not approximately directly proportional to stress) appears to be slightly higher in welded than in unwelded material.
(*d*) The modulus of elasticity of a small test piece, entirely composed of material of the weld, was about 11,700 tons per square inch, as compared with about 13,500 tons for mild steel and about 12,500 tons for wrought iron.

2. *Ultimate strength and ultimate elongation.*
(*a*) The ultimate strength of welded material with small specimens was over 100 per cent. of the strength of the unwelded steel plate for thicknesses of ¼ in., and averaged 90 per cent. for plates of ½ in. and 1 in. in thickness.
(*b*) Up to the point of fracture the extensions of the welded specimens are not sensibly different from those of similar unwelded material.
(*c*) At stresses greater than the elastic limit, the welded material is less ductile than mild steel, and the ultimate elongation of a welded specimen when measured on a length of 8 in., only averages about 10 per cent. as compared with 25 per cent. to 30 per cent. for mild steel.

3. *Alternating stresses.*
(*a*) Rotating specimen (round bar) :
(1) Unwelded turned bars will withstand a very large number of repetitions of stress (exceeding, say, 5,000,000), when the range of stress is not greater than from 10½ tons per square inch tension to 10½ tons per square inch compression.
(2) Welded bars similarly tested will fail at about the same number of reversals, when the range of stress exceeds ± 6½ tons per square inch.
(*b*) Stationary test pieces (flat plate) :
(1) Butt-welded specimens will withstand about 70 per cent. of the number of repetitions which can be borne by an unwelded plate.
(2) Lap-welded plates can endure over 60 per cent. of the number of alternations necessary to fracture a lap-riveted specimen.

4. *Minor tests.*
(*a*) Welded specimens are not capable of being bent (without fracture) over the prescribed radius to more than about 80 deg. with ¼-in. plate, reducing to some 20 deg. where the thickness is 1 in. Unwelded material under the same conditions can be bent through 180 deg.
(*b*) Welded plates can withstand impact with a considerable degree of success; a ¼-in. plate of dimensions already quoted sustained two successive blows of 4 cwt. dropped through 12 ft., giving a deflection of 12 in. on a length of about 4 ft. 6 in. without any signs of fracture in the weld.

5. *Chemical and microscopic analysis.*
(*a*) Chemical analysis.
(1) The electrode was practically identical with mild steel, but there was a greater percentage of silicon.
(2) The material of the weld after deposition was ascertained to be practically pure iron, the various other contents being carbon, ·03; silicon, ·02; phosphorus, ·02; and manganese, ·04 per cent. respectively.

(*b*) Microscopic examination.
(1) The material of the weld is practically pure iron.
(2) The local effect of heat does not appear largely to affect the surrounding material, the structure not being much disturbed at about ⅛ of an inch from the edge of the weld. The amount of disturbance is still less in thin plates.
(3) The weld bears little evidence, if any, of the occurrence of oxidation.
(4) With welds made as for these experiments, *i.e.*, with flat horizontal welding, a sound junction is obtained between the plate and the welding material.

6. *Strength of welds (large specimens).*
(*a*) Butt welds have a tensile strength varying from 90 per cent. to 95 per cent. of the tensile strength of the unwelded plate.
(*b*) Lap welds.
(1) With full fillets on both edges the ultimate strength in tension varies from 70 per cent. to 80 per cent. of that of the unwelded material.
(2) With a full fillet on one edge and a single run inferior to those where a full fillet is provided for both edges.
(*c*) Riveted lap joints : For plates of about ¼ in. in thickness, the specimens averaged about 65 per cent. to 70 per cent. of the strength of the unperforated plate.

OBSERVATIONS ON EXPERIMENTAL RESULTS.

(1) *Static elasticity.*—It will be observed that the statical tests made to determine the elasticity indicate that, in general, the combination of welded and unwelded material behaves practically homogeneously up to at least the elastic limit. Moreover, the experiments show that the process of welding is such that the stress is distributed practically uniformly over the weld, and also transmitted uniformly to the adjacent plates.

The material of the weld is practically pure iron, and from the tests made on a specimen composed entirely of the deposited material of a weld, it will be seen that for given stress the weld stretches slightly more than mild steel. This property will enable any undue occurrence of load to be transferred in a proper manner to adjacent portions of the structure. When, however, the stress exceeds the elastic limit and is so great that the extension grows continuously without increase of load, the welded material fails sooner than mild steel. This disadvantage is, however, of little practical importance in shipbuilding, and may be regarded as negligible in the particular problem under consideration.

(2) *Dynamic elasticity.*—In a structure, such as a ship, which is exposed to variations and reversal of stresses, it is extremely important to know whether the material to be used is likely to break down rapidly under such alterations and ranges of stress as are likely to be experienced. The modified Wohler tests employed in the experiments certainly indicate, if considered solely by themselves, that whereas for a given number of alternations mild steel would withstand a range of stress of, say ± 10½ tons, the welded material might be expected to fail at about ± 6½ tons, a figure which is more nearly experienced in ordinary ship construction.

It would appear to be necessary to design the welded joints in such a manner that the amount of work likely to be thrown on the joint is as small as possible, and to meet such a condition a welded joint requires to be either lapped or strapped.

It will be noticed that the material in the weld appears be to nearly pure iron, and experiments of repetitive stress show that wrought iron bars are likely to fail under a range of stress of perhaps ± 7 tons to 8 tons, as compared with mild steel at ± 10 tons to 11 tons. The weld has to be deposited electrically and is subject to variations in workmanship; it would consequently be considered satisfactory if the material could withstand a range of stress of, say, ± 6½ tons.

Consideration of the dynamic elasticity of properties appears to show that in any case the welded material can experience as large a number of repetitions of stress as wrought iron could do, and it is always recognised that although iron could not approach the tests for mild steel, yet it was a satisfactory material for shipbuilding purposes. Further, attention to design of detail will increase the performance of the welded joint, and in addition it must not be forgotten that 5,000,000 repetitions of stress is perhaps more than equivalent to 10 years' good sea service.

(3) *Physical Nature and Properties.*—It has been mentioned that the welds experimented with are to be regarded as having been produced under most favourable conditions, and that throughout the experiments welds were made with the specimens horizontal and below the operator. In practice, welds will require to be made vertically and overhead as well, consequently, extreme care will be required in such operations.

The physical examinations indicate that the materials of the electrode and the system of welding adopted were suitable and reliable. Moreover, there was little apparent oxidation and the material in the neighbourhood of the weld was not affected to any prejudicial extent.

(4) *Strength of large welds.*—Broadly speaking, the tensile strength of butt welds was as great as the unwelded material, but it is considered that greater reliability of workmanship is obtained with joints which are either lapped or strapped.

It was also found that the lapped joint was practically as strong as a riveted lapped joint and would probably remain tight when subjected to more trying conditions than are necessary to disturb a riveted lap joint.

A meeting of the technical committee of Lloyd's Register to consider the application of the results of these tests, was held on the 25th ult., when it was decided that there appeared to be sufficient justification for the extension of the process of arc-welding to the connection of the main structural portions of ships. Such application should, however, only proceed cautiously in view of the unknown factors involved, in the development of the most important of which are the need of experience with the details of the welded joints, and the necessity of training skilled workmen and supervisors.

After full consideration of the subject the technical committee decided to recommend to the general committee that provisional rules, as proposed by the chief ship surveyor, should be adopted for the application of electric arc-welding to shipbuilding, and that the approval of the society should be given to any process which complies with such regulations.

A special meeting of the general committee was held on Thursday, the 15th inst., to receive the report of the technical committee, and it was decided that the subjoined regulations should be adopted as a tentative measure.

TENTATIVE REGULATIONS FOR THE APPLICATION OF ELECTRIC ARC WELDING TO SHIP CONSTRUCTION.

(*a*) *System of Welding and Workmanship.*

1. The system of welding proposed to be used must be approved and must comply with the regulations and tests laid down by the committee.

2. The process of manufacture of the electrodes must be such as to ensure reliability and uniformity in the finished article.

3. Specimens of the finished electrodes, together with specifications of the nature of the electrodes, must be supplied to the committee for purposes of record.

4. The committee's officers shall have access to the works where the electrodes are manufactured, and will investigate, from time to time as may be necessary, the process of manufacture to ensure that the electrodes are identical with the approved specimens.

5. Alterations from the process approved for the manufacture of electrodes shall not be made without the consent of the committee.

6. The regulations for the voltage and amperage to be used with each size of electrode, and for the size of electrode to be employed with different thicknesses of material to be joined, are to be approved by the committee.

7. The committee must be satisfied that the operators engaged are specially trained, and are experienced and efficient in the use of the welding system proposed to be employed.

8. Efficient supervisors of proved ability must be provided, and the proportion of supervisors to welders must be submitted for approval.

(*b*) *Details of Construction.*

9. The details of construction of the vessel and of the welds are to be submitted for approval.

10. Before welding, the surfaces to be joined must be fitted close to each other and the methods to be adopted for this purpose are to be approved.

11. All butt and edge connections are to be lapped or strapped.

12. With lapped connections the breadths of overlaps of butts and seams and the profiles of the welds are to be in accordance with the following table :—

Thickness of plate.	Width of overlap seam and butt.	Total thickness.
In.	In.	In.
·40 and under ...	2½	·28
·60	2½	·38
·80	2½	·48
1·00	3	·50

Intermediate values may be obtained by direct interpolation, and for thicknesses below ·40 the throat

thickness is to be about 70 per cent. of the thickness of the plate.

13. A "full weld" extends from the edge of a plate for a distance equal to the thickness of plate to be attached, and the minimum measurement from the inner edge of plate to the surface of weld is the throat thickness given in the table above.

14. A "light closing weld" is a single run of light welding worked continuously along the edge of the plate. Such a weld may, however, be interrupted where it crosses the connection of another member of the structure.

15. An "intermittent or tack weld" has short lengths of weld which are spaced three times the length of the weld from centre to centre of each short length of weld. Such tack welding may vary in amount of weld between a "full weld" and a "light closing weld."

16. The general character of welds is to be in accordance with the following table:—

	Inside edge.	Outside edge.
(*a*) Butts of shell, deck and inner bottom plating	F	F
(*b*) Butts of longitudinal girders and hatch coamings		
(*c*) Edges of shell, deck and inner bottom plating	L	F
(*d*) Butts and edges of bulkhead plating		
	Toe.	Heel.
(*e*) Frames to shell, reverse frames to frames and floors	T	L
(*f*) Beams to decks		
(*g*) Longitudinal continuous angles		
(*h*) Side girders, bars to shell, intercostal plates, floors and inner bottom		
(*i*) Bulkhead stiffeners		

F = full weld, L = light weld, and T = tack weld.

17. All bars required to be watertight are to have continuous welding on both flanges with tack welding at heel of bar.

18. The welded connections of beam, frame and other brackets are to be submitted for special consideration.

19. The committee may require, when considered necessary, additional attachment beyond that specified above, and the welding of all other parts is to be to their approval.

As is customary when a new process of construction, of which experience in conditions analogous to those which are met with in ships is not available, is proposed to be adopted in vessels classed by Lloyd's Register, the committee have decided that the classification will be subject to the notation "experimental," and a record of "electrically welded" will also be made in the society's register book.

It is unnecessary to enlarge on the importance of the step now taken, and the rivetless ship, at one time considered only as an unattainable ideal, is now well on the way to becoming an accomplished fact.

The prompt and energetic manner in which the possibilities of electric welding have been investigated by Lloyd's Register is worthy of the best traditions of the society, and the vigour and initiative of the present *régime* bids fair to secure for that Institution an even more preponderating position than it has filled in the past.

"COAL SAVING BY SCIENTIFIC CONTROL OF BOILER PLANTS."

To the Editor of Engineering.

Sir,—The article on coal saving by Mr. Brownlie which appeared in two of your recent issues of Engineering is extremely interesting. Whilst not in agreement with the author on one or two technical points the questions raised are, as I believe no one will dispute, highly important in view of the present coal shortage. The inferences the author draws from the results of his 250 tests on boiler plants are startling, and point to the need of something drastic being done immediately if we are to maintain the present steam output from the country's boiler plants with our reduced coal supply.

Most engineers who have had even the smallest experience of boiler plants know that these are being run on most inefficient lines, and in a manner that would not be tolerated in any other branch of engineering industry. This seems to be because an efficiency test of a boiler plant is not nearly so easily carried out as is a similar test of most other engineering appliances, requiring as it does the combination of chemistry and engineering.

The result is that the boilerhouse staff are working their plant in complete ignorance of its performance. If, however, a test of the plant is carried out it is the work of the specialist to discover the weak points about the plant, that is, the points which are causing the loss in efficiency. There must be a large number of boiler plants in this country which are being run in a most wasteful manner, because they have never been tested for efficiency, thus the weak points which are causing the loss remain undiscovered.

What is happening to-day is this:—A firm whose boiler plant is running, say, only 60 per cent. efficiency (but not known) are short of steam, and order a new boiler, which when erected causes them to be quite at a loss to find extra coal to run it. The cost of the new boiler, setting, &c., would cover, and probably more than cover the cost of testing and bringing up-to-date their present plant, which if this were done would in many cases give them the extra steam they require without any increase in their coal consumption, which in some cases might even be reduced.

It is high time the Government Departments concerned with coal economy made a serious effort to deal at once with this question, so that the more important concerns at any rate can have their boiler plants running more economically in time to meet the serious coal shortage before it becomes more acute.

The time has undoubtedly arrived for plain speaking in this matter and it ought to be stated clearly that Priority Certificates for additional boilers for a plant ought not to be granted unless that particular plant is running on an efficiency of, say, 70 per cent. to 75 per cent., and if this result is not attained, then the priorities required are those which will enable the reorganisation of the existing plant to be carried out. The reorganised plant would then in most cases give such an increased output that additional boilers would not be necessary.

This is surely the only sensible method of dealing with this serious question of coal economy, and it is to be hoped that owners of boiler plants throughout the country will act on the principle of bringing their present plants up-to-date and thereby increasing the output before considering the question of ordering new boilers.

"Research."

Manchester.

To the Editor of Engineering.

Sir,—The article on "Coal Saving by Scientific Control of Boiler Plants," by Mr. D. Brownlie, together with subsequent discussion, is very appropriate at the present time.

The fact of Messrs. Brownlie and Green, Limited, being called in to examine these 250 plants leads one to think that the owners of the plant are rather keen towards efficiency, therefore these plants would likely be more efficient than those belonging to other people who never trouble about scientific examinations. If this is so, then the general efficiency of the other plants would be much less. I suggest, sir, that it would be interesting to have balance charts made from some of these plants, thus one could see at a glance where the faults of the plant lay.

One would easily see the advantages or disadvantages of the placing of various types of boilers, superheaters, economisers, or method of draft production. Generally speaking, I find there is room for vast improvement with the stokers as regards their knowledge of combustion of fuel, and although a boiler house is not an ideal place for the owner or engineer to stay in long yet a few hours spent there is a good investment.

Most of us know that coal has been absolutely thrown away—we get it too cheap—and also that it is possible to get ever so much more from it than we have hitherto done. But it is no use crying over spilt milk, we must make the most of existing plant till the day comes when isolated steam generation will be a thing of the past. At the same time I regret that Mr. Brownlie did not go beyond the call at the boiler house.

What a field there is for improvement in the supply of fuel to the stokehold; look at the toys (comparatively speaking) we send all over the country holding from 7 to 10 tons of coal, and even when you get it it has to be thrown out by hand labour.

In the States and also Canada this fuel is handled in 50 to 60-ton cars, self-discharging; why even the coal retail merchant sends along his horse wagon carrying 9 tons of coal, the driver backs his cart to the spout of a loader, opens the door of the wagon and starts the loader at a ton to 2 tons per minute, stops the plant, then off before our man would have time to put the nosebag on.

Then later on, after the steam is generated even at 80 per cent. boiler efficiency, what percentage of the power in the original coal is actually given off at the manufacture. It would be interesting if Mr. Brownlie could supply this figure. I query if this would exceed an average of 5 per cent.

I am, Sir, yours faithfully,

John H. Anderson.

Purfleet, Essex.

To the Editor of Engineering.

Sir,—In replying to my letter of the 9th inst. Mr. D. Brownlie gives points to mechanical draught, over natural draught for high duties, with which I thoroughly agree; but even then 35 lbs. of fuel per square foot of grate per hour in Lancashire boilers is not *easily obtained* and seldom maintained over a period. Before figures like this are reached, a better class of stoker will be required, or in other words more money and better conditions of employment will have to be provided. Concerning my criticism of 8-ft. diameter boilers, my views are with the dead plate 3 ft. 9 in. high and a depth of grate 7 ft. 6 in. it is extremely difficult to fire efficiently, and consequently much waste occurs. The author is apparently cognisant of this, as I note he recommends 5 ft. to 5 ft. 6 in., and with this diminution his evaporation figure per boiler must surely drop? I should, in conclusion, also like to know the author's views of the settings generally adopted for Lancashire boilers, as I am convinced that, together with faulty chimney design, it is in them our troubles lie.

Yours faithfully,

August 20, 1918. "Morgan."

To the Editor of Engineering.

Sir,—Mr. Brownlie's letter in your issue of August 16 calls for further remarks as to evaporation with reference to heating surface.

An analytical examination of boiler test results shows that maximum efficiency in a well-designed boiler is obtained when the rate of evaporation is about 3 lbs. to 4 lbs. per square foot of heating surface; also that maximum efficiency of combustion is obtained when burning fuel at rates between 16 lbs. and 24 lbs. per square foot of grate surface according to the draught available and provided the amount of air supplied is efficiently controlled, and it may be expected that with a well designed boiler working within the above figures good results will be obtained, and that any considerable departure from these limits will be accompanied by a loss of efficiency.

A boiler worked at an evaporative rate of 9 lbs. or 10 lbs. steam per square foot of heating surface will give an efficiency about 10 per cent. less than that obtained with an evaporation of about 3 lbs. per square foot provided the fuel is burnt efficiently in both cases.

On account of the size and other considerations a boiler is usually designed for evaporation of 6 lbs. to 8 lbs. per square foot of heating surface for fuel duty; if, however, circumstances allow the boiler to be run at a lower rate, it would be beneficial temporarily to reduce the grate surface in order that the more efficient rate of evaporation can be accompanied by the most efficient rate of combustion according to the draught available. A ready means of regulating the area of grate to keep it within its economical limits in some cases would be desirable when working a boiler at other than its norma rate.

Yours faithfully,

Glasgow, August 20. J. W.

TESTING AIR COMPRESSORS.

To the Editor of Engineering.

Sir,—With reference to W. W. F.'s letter of July 30, the best method of varying the output, and there are many, is one of which I should like to see test figures published. In the compressor in question the air is regulated, not by throttling as W. W. F. suggests, but by completely closing the inlet and again opening it fully when the air pressure in the receivers has fallen. The compressor thus works either at full or no load. A partial vacuum is formed in the first stage cylinder and to some degree in the second stage, and this I should expect to be more efficient than holding the inlet valves open and churning the air in and out. Possibly in this particular American practice for once lags behind the English.

I should like to give fuller particulars of the construction of the machine, but you will understand that the construction details of the machine are given by the manufacturers to me, as is usual, in confidence, and the manufacturers cannot be expected to publish the details for the benefit of competitors.

The cylinder dimensions are as follow:—First stage, 36 in.; second stage, 21 in.; stroke, 17 in.

I am sorry Mr. Fairley does not like pump-up tests, but what better test is there? The tests in question were very carefully taken and, I believe, are correct. I certainly think it would be a great advantage if the Engineering Standards Committee would standardise a set of orifices for air and determine the co-efficients experimentally—all compressors could then be tested in the same manner.

Now with regard to the no-load tests, air was admitted to the cylinders by means of the indicator cocks so that the clearance spaces were filled. Further, as Mr. Fairley surmises, there was a slight air leakage past the packings.

With regard to closing the inlet and opening the delivery valve to atmosphere, this method has its advocates, but it seems additional complication. It is used sometimes, with motors fitted with automatic starters to relieve the starting torque. I have seen an experiment made on a machine that had been running more than a year to test the value of this device, and the difference in the power taken at no load, compared with the method described in my article, was negligible. The delivery valves must of course have been airtight, though no examination was made.

I do not want to convince Mr. Fairley that Bellis compressors are the best (I hold no brief for Bellis and Morcom) and if any other manufacturer can guarantee and obtain better results I shall be only too pleased.

Perhaps Mr. Fairley can give some independent figures for comparison.

Yours faithfully,

N. S. Tennant.

38, Grainger-street West, Newcastle-on-Tyne.
August 15, 1918.

The Late Sir George Benjamin Hingley, Bart.—We regret to have to announce the death, which occurred last Monday at his residence, High Park, near Droitwich, of Sir George Benjamin Hingley, Bart., the well-known ironmaster. Sir George was the eldest son of the late Mr. Hezekiah Hingley, and nephew of the late Sir George Hingley, Bart., to whom he succeeded in the baronetcy. He was the grand-nephew of Mr. Noah Hingley, the founder of the firm of N. Hingley & Sons. He was educated at Halesowen Grammar School, and after travelling abroad, he became associated with the great industrial concerns and mining enterprises of the firm. He took over the control of the works and mines at the death of his uncle, Sir Benjamin Hingley. Sir George was a recognised authority on the South Staffordshire iron industry. He was a member of the Midland Iron and Steel Wages Board, of the South Staffordshire Mines Drainage Commission, and served on deputations to the Ministry of Munitions in relation to prices and wages. He was chairman of N. Hingley & Sons, Ltd., Hart's Hill Iron Company, and of Lloyd's British Testing Company. He was also a county magistrate and an alderman of the County Council of Worcestershire. He had held the appointment of High Sheriff of Worcestershire, and at the time of his death was Deputy-Lieutenant of the county. Sir George was in his sixty-eighth year. He was since 1889 a member of the Iron and Steel Institute.

TWIN-SCREW PASSENGER STEAMER "STAVANGERFJORD."

(*Concluded from page* 172.)

In our last issue we gave an illustrated general description of the Stavangerfjord and of her passenger accommodation. On Plate XVIII with our present issue we illustrate the location of the engines and boilers; Fig. 22, on Plate XVIII, being a longitudinal section of the vessel showing the engine and boiler rooms amidships, from frame 66 to frame 138; the engine and boiler rooms being further illustrated in the plans. Figs. 24 and 25, on the same plate, are vertical sections through the engine rooms at frame 88, looking aft and looking forward respectively; Fig. 26 is a plan of the chimneys; whilst Fig. 27 on this page is a vertical section through the boiler room.

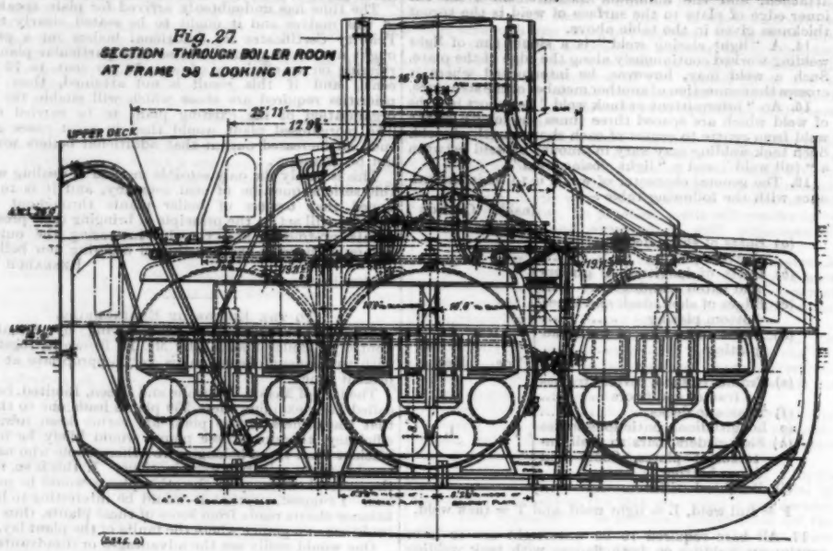
The main propelling machinery consists of two sets of twin screw, direct acting, quadruple expansion engines, having cylinders 26½ in., 37½ in., 53 in., and 76 in., by a 54 in. stroke, designed for running at about 95 revolutions per minute. The engines are balanced on the Yarrow-Schlick-Tweedy principle. The main condenser bodies are of mild steel, and the doors and water ends of cast iron. The whole of the shafting has been manufactured at Messrs. Cammell Laird's own works, Sheffield. The propellers are of the built up type, with special cast iron bosses. Two sets of Weir independent air pumps are fitted in connection with the main machinery, and also three sets of Weir direct-acting feed pumps. Feed filters are provided in connection with the feed arrangements; an auxiliary condenser deals with the exhaust from the auxiliary machinery. The vessel carries bilge and ballast pumps of extra large capacity, the pumping arrangements being in accordance with the International Conventions' requirements. Loud speaking telephones are fitted between the bridge and the engine room.

The boiler installation consists of eight single-ended boilers 16 ft. 4½ in. in diameter, by 11 ft. 8 in. long, provided with Hovden's system of forced draught. Ash ejectors are in each of the stokeholds in addition to the ordinary steam-driven ash hoists.

The whole of the machinery has been constructed to the requirements of the Board of Trade, Lloyds' Register of Shipping, the Norwegian Government requirements, the Norske Veritas, and the American Government requirements.

THE T.S.S. "STAVANGERFJORD."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.



INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics states in *The Labour Gazette* that in July employment continued good in nearly all the principal industries, and much overtime was worked by inadequate staffs. In the cotton and jute trades, however, it continued to be restricted by the regulation of the consumption of raw materials, and short time was worked.

Trade unions with a net membership of 1,124,227, excluding those serving with the forces, reported 0·6 per cent. of their members as unemployed at the end of July, compared with 0·7 per cent. at the end of June and 0·4 per cent. at the end of July, 1917. The increase in the percentage as compared with a year ago was almost entirely due to the cotton industry.

Of the 3,921,878 male and female workpeople insured under the National Insurance Acts, 1911 to 1916, the number unemployed at the end of July was 26,442, or 0·67 per cent., compared with 0·79 per cent. in the previous month and 0·69 per cent. a year ago. For males and females separately the percentages unemployed at the end of July were 0·34 and 1·34.

The average weekly number of vacancies notified to all Employment Exchanges for the five weeks ended July 12, 1918, was 44,735, as compared with 43,948 in the previous four weeks, and with 36,904 in the five weeks ended July 13, 1917. The average weekly number of vacancies filled for the same periods was 33,950, 33,558 and 28,822 respectively. The number of workpeople remaining on the live register at July 12, 1918, was 30,661 men, 53,949 women, 7,574 boys and 7,321 girls, a total of 99,505.

The changes in rates of wages (including war bonuses) reported to the department as having been granted in July, resulted in a net increase of nearly 100,000*l.* per week in the wages of over 400,000 workpeople.

The principal changes recorded were an increase of 5*s.* per week in the war advance granted to tramway and omnibus workmen, and increases of varied amounts in the textile bleaching, printing, dyeing, &c., trades in the North of England and Scotland, and to workpeople in the wholesale clothing trade. Other important increases included bonuses of 12½ per cent. and 7½ per cent. on the earnings of building trade operatives on time and piece rates respectively in Scotland, a further war advance of 1½*d.* per hour to building trade operatives on munitions work in London, and additional war bonuses to steel and tinplate workers in South Wales and Monmouthshire.

The number of disputes beginning in July was 90, and the total number of workpeople involved in all disputes in progress was 96,900, as compared with 70,100 in the previous month, and 45,400 in July, 1917. The estimated total aggregate duration of all disputes during the month was 582,500 days, as compared with 375,100 days in June, 1918, and 260,600 days in July, 1917, respectively.

In the course of a speech which he delivered on the 15th inst. at the Mansion House, under the auspices of the British Empire League, Mr. W. M. Hughes, the Premier of Australia, stated the following:—

". . . We are fighting a life and death struggle with Germany, who is out to secure economic domination of the world, and we must take such steps as are necessary to secure our economic welfare in order that we may ensure our national safety. If Germany is allowed to secure our raw materials either directly or indirectly, then her national greatness will wax and ours will wane. What I want is a policy that will ensure to Britain and her Allies too, an adequate supply of raw materials, that will encourage the production of such raw materials as the Empire produces or can produce, will prevent this or any other market within the Empire being the dumping ground of German goods, will enable Britain and the other parts of the Empire to hold their own in the home and foreign markets. If my friends, to whom a tariff is anathema, can formulate such a policy, why do they not do so? Why do they range themselves alongside the Germans in our midst, and support the very policy that Germany desires we should do? I have no quarrel with any man because he believes in Free Trade. I do not pin my faith to tariffs, but to organisation, or, in other words, to the adoption by each industry of such methods as will equip it most effectively for the competition for trade after the war. To every disease apply the appropriate remedy, but in such cases where the remedy called for is clearly a tariff or a bonus, are we to hesitate to apply it because in 1849 somebody said or did something, or because such action will annoy Germany? Although the Government has not definitely declared its general economic policy, it has taken certain steps which are quite incompatible with a return to the *status quo ante bellum* policy, but whatever has been done is but a fraction of what we yet must do. If you inquire whether duties alone will suffice to keep the market for the British producer, I say frankly that in some cases they cannot. We must look at this question as a lock-keeper looks at the water running from the high level into his dock. We must regulate, we must control trade so that it serves our interests, national and economic. Every industry should be given the encouragement that its circumstances demand. There is not one thing to do, but many; and you might as well dictate a hard-and-fast policy to a captain of a ship as endeavour to lay down a formula by which this nation can be saved. . . ."

Sir A. D. Steel Maitland, M.P., representing the Board of Trade, formally opened the second British Industry Fair at Glasgow last Monday. The Fair is being held in the Kelvin Hall of Industries, Kelvingrove, and will remain open for a fortnight. All the floor space, about 100,000 sq. ft., has been fully taxed to accommodate the display made by many of the leading British manufacturers. The Fair is promoted by the Corporation of Glasgow, under the auspices and with the support of the Board of Trade, and is under the patronage of the Associated Chambers of Commerce, London, and the Glasgow Chamber of Commerce.

In the course of his speech Sir Arthur said that the great fairs at Lyons, London and Glasgow were meant as a means of preparation for the future. The difficulties in the post-war period would be great. They would have the difficulties of the transition period from war to peace after they had won the victory, and later those of the normal period of peace which followed. The first thing they had to look to was that they were building for the future, and that we and our Allies when the war was over had got to work together, not separately, to build up the ravages created by the war. Our primary obligation was to restore those countries that had suffered most—Belgium, Serbia, and the ravaged parts of France and Rumania. We and our Allies must face that work together, in order that we who had stood shoulder to shoulder in all the trouble of the war should stand shoulder to shoulder without jealousy in the work of commerce and reconstruction that would follow.

That co-operation was the first principle; the other was that each of the partners must be as efficiently equipped for that work as possible if they were to play their share. They must, therefore, equip themselves for the task. They could manufacture to the same extent as before the war, but they could think beforehand and plan also. Then when the opportunity was given them they could do something to repair the ravages which the war had caused, and to build up our own country with those of our Allies and our foreign trade again.

In declaring the fair open, he wished it the heartiest success and trusted it would be one of the means by which good might come out of the whole incalculable evil which the war had wrought.

Speaking at a complimentary luncheon prior to the opening, Sir Arthur referred to the work of the Board of Trade. No great department could do for the trader the business the trader could successfully do for himself. He was convinced that if after the war we were to regain and surpass our old position in the export trade, on which this country largely depended, we could only do so by learning from the faults of the past, and by the co-operation of one branch of trade and industry with another much more readily and open-heartedly than in the past. We must have a much closer connection between organised finance and transport, and manufacturers and merchants. The success of such a fair would not be less to the exhibitors because the fruits might not come until times were better and materials were ready to hand to fulfil orders.

Shipbuilding in Hong Kong.—According to Reuter, the first steel standard ship built in China was launched a few days ago at Hong Kong from the Whampoa Dock Company's yard.

MULTIPLE EFFECT COMPRESSION ICE-MAKING AND REFRIGERATING MACHINES.

On this page, and on page 204, we illustrate a type of CO_2 refrigerating machine which differs from the ordinary compression machine in that the compressor is designed to take in its charge at two different pressures, and this is then compressed into the condenser by a single stroke of the piston. This peculiarity enables two evaporations of the refrigerating gas to be made, one after the other, at different pressures and corresponding temperatures in the same cycle of operations; thus, the primary evaporation may be arranged for in one vessel at 20 deg. F., whilst a lower temperature is obtainable in another evaporator at, say, 0 deg. F., and the suitable pressures in the two evaporators will be maintained by one compressor; the low pressure gas from the low temperature evaporator first enters and fills the cylinder. A second charge is then allowed to enter from the high-pressure evaporator, thus partly compressing the first charge and the double charge is then compressed into the compressor by the return stroke of the piston.

By making use of the primary evaporation to thoroughly cool and liquefy the CO_2 refrigerating gas before it reaches the low temperature evaporator, these machines are, it is claimed, not only able to work with increased efficiency in temperate climates, but will keep within 10 per cent. or 12 per cent. of this efficiency during a passage through tropical regions. In short, it is claimed that a machine built on the multiple effect compression system, weight for weight, will start with 25 per cent. more efficiency in this country and will have more than double the refrigerating power of an ordinary compression machine when it arrives in tropical regions.

The results of some comparative tests are illustrated by Fig. 1, where the lower line represents the figure obtained in careful trials of an ordinary compression machine which was subsequently altered to multiple effect compression with a compressor of the same piston displacement. The results obtained upon this modification are represented by the upper line on the diagram. The improvement was entirely due to the constant low temperature at which the CO_2 gas was fed to the evaporator, whilst the great falling off in efficiency of the ordinary compression, shown by the lower line on the diagram, was caused by the varying temperature of the CO_2 as it reached the evaporator.

On these trials the CO_2 served to the evaporator from the multiple effect receiver after being partially evaporated was never higher than 25 deg. F. under all conditions of temperature of the cooling water; whilst with the ordinary compression machines the temperature of the CO_2 coming direct from the CO_2 condenser varied from about 62 deg. to 95 deg. F. according to the temperature of the cooling water, and this heat being allowed to enter the evaporator caused the loss of efficiency.

The general arrangement of the multiple effect compression cycle of operations is shown by diagram Fig. 2, where the path of the CO_2 from the compressor cylinder to the condenser, receiver and evaporator and back to the cylinder is clearly shown by the arrows.

Fig. 1. CO_2 REFRIGERATING MACHINES ORDINARY & MULTIPLE EFFECT COMPRESSION.

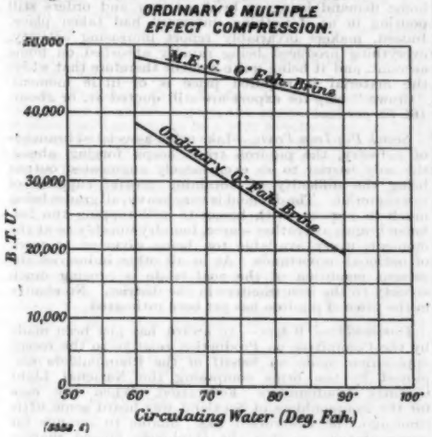


Fig. 2. DIAGRAM SHOWING WORKING CYCLE OF MULTIPLE EFFECT COMPRESSION.

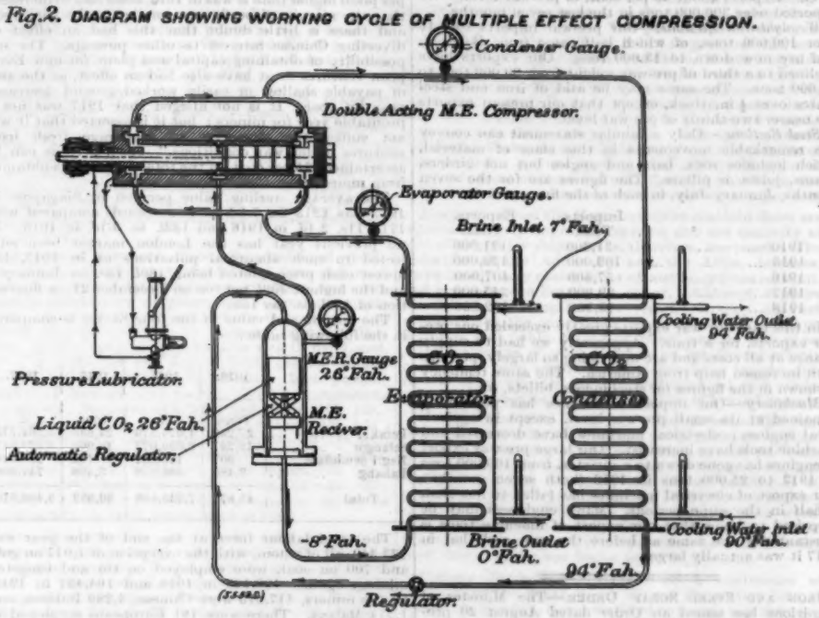


Fig. 3.

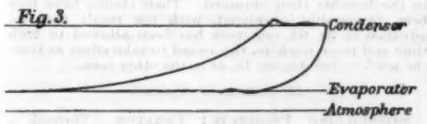


Fig. 4.

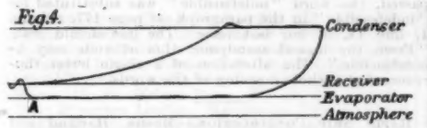
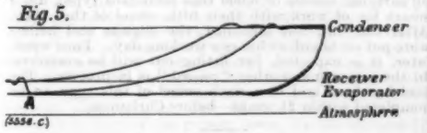


Fig. 5.



Indicator diagrams from the compressor cylinder are reproduced in Figs. 3, 4 and 5. Diagram Fig. 3 shows the ordinary card, before the alteration to the multiple effect system. Diagram Fig. 4 was taken after the alteration, and Fig. 5 shows the two cards superimposed, thus setting both the difference between them.

Although the multiple effect diagram is seen to be much larger in area than the ordinary one the power necessary for compression is not proportionately greater, for that portion of the diagram which is between the lines indicating the pressures in the evaporator and the receiver is obtained without a corresponding expenditure of energy by allowing the charge of gas from the receiver or high-pressure evaporator to enter the cylinder on top of the charge which had been first received from the low-pressure evaporator. The entrance of this second high-pressure charge has the effect of raising the pressure of the first charge in the cylinder to its own pressure without any mechanical effort at the moment when the piston is at the end of its stroke.

In actual practice a machine which was altered from ordinary to multiple effect compression gave under tropical conditions 130 per cent. more refrigeration for an increase of only 54 per cent. in the horse-power. Two other machines working at moderate temperatures in this country after alteration increased their output 64 per cent. for an expenditure of 38 per cent. more horse-power.

These two examples are, it is stated, a fair average of what may be obtained under different working conditions.

In Fig. 6, page 204, we reproduce a photograph showing a No. 4 unit Marine type multiple effect compression CO_2 refrigerating machine driven by a cross-compound steam engine and having all its parts duplicated.

It is claimed by the makers for this No. 4 machine that in the tropics it will be fully equal in output to a No. 7 1/2 unit ordinary compression machine. The weight saved is therefore very considerable.

Taking advantage of this system the makers have recently built several small compact marine type ice-making and refrigerating machines for hospital ships for service on the river Tigris, which are represented in Fig. 7. In this case the machine is, it will be seen, driven by an electric motor. Owing to the adoption of this multiple effect system it became possible to make these machines 28 per cent. lighter than the ordinary type, and they gave, moreover, 32 per cent. more ice for the same horse-power, or 60 per cent. more ice than was previously possible with slow running machines of this size.

These machines are very compact and may be placed in the corner of any engine room and require only two working sides. They are self-contained and carry their own sea water and cold brine circulating pumps, CO_2 condenser and evaporator, and may be overhauled in the small space provided by the two alley ways. They are built for an output of 5 cwt. of ice per day and will at the same time cool the ship's provision store.

The machines illustrated were built by Messrs. Seagers, Limited, refrigerating engineers, of Dartford, Kent, under the patents of Mr. Gardiner T. Voorhees, and Sir William Stokes.

VANADIUM IN SWEDEN.—Vanadium deposits at Trysenda, in the Ornskildsund archipelago are about to be worked at the instance of a Stockholm syndicate; the percentage of vanadium amounts to as much as 1 per cent., which is considered quite satisfactory, and the new undertaking is expected to prove of much value to the Swedish steel industry.

LOSSES OF MERCHANT TONNAGE.—The Secretary of the Admiralty makes the following announcement:—The losses of British, allied and neutral merchant tonnage due to enemy action and marine risk during the month of July, 1918, compared with preceding periods, are set out below:—

Gross Tonnage.

Period.	British.	Allied and Neutral.	Total.
Second quarter, 1917	1,361,870	875,064	2,236,934
Third quarter, 1917 ..	952,938	541,535	1,494,473
Fourth quarter, 1917	782,889	489,954	1,272,843
First quarter, 1918 ..	697,497	445,318	1,142,815
April, 1918	228,087	85,348	313,415
May, 1918	231,780	132,703	364,483
June, 1918	165,514	115,980	281,494
July, 1918	176,479	136,532	313,011

The tonnage of steamships of 500 gross tons and over entering and clearing United Kingdom ports from and to ports overseas was as under:—

Period.	Gross Tons.
January, 1918	6,236,662
February, 1918	6,826,965
March, 1918	7,295,620
April, 1918	7,040,309
May, 1918	7,777,843
June, 1918	7,430,386
July, 1918	7,718,398

This statement embraces all United Kingdom seaborne traffic other than coastwise and cross-Channel. The statement adds that the British losses in July exceeded the building in United Kingdom yards by 34,531 gross tons; but in the same month 12,220 gross tons were completed abroad on British account, reducing the deficit to 22,311 gross tons, compared with a monthly average deficit during the first six months of this year of nearly 90,000 gross tons.

ENGINEERING IMPORTS AND EXPORTS.

The official monthly trade return now issued shows the imports and exports for the seven months January-July, of this year, and the same periods of 1916 and 1917. In some products the figures may represent "trade" but in engineering materials and finished products (so far as these are shown at all) they represent "permitted" quantities. The permits are made out to adjust war supplies amongst the Allies, irrespective of commercial considerations. It will be sufficient, therefore, to give a note of the general tendencies and the relation to pre-war levels.

Coal, Coke and Fuel.—Imports were never more than nominal. Exports are steadily declining and are half the pre-war quantity.

Iron Ore.—Tonnage of imports not given while the value shows a slight increase in the three years. Pre-war imports were 4,500,000 tons. Pre-war exports only 4,000 tons, now practically nil.

Pig-iron.—Imports nearly 70 per cent. of pre-war level. Exports about 45 per cent. of pre-war level. We exported over 300,000 tons in the last seven months.

Wrought-iron Sections.—Our pre-war imports rose to over 100,000 tons, of which half came from Belgium, and are now down to 13,000 tons. Our exports have declined to a third of pre-war weight from 90,000 tons to 28,600 tons. The same may be said of iron and steel plates over ¼ in. thick, except that our present exports are nearer two-thirds of pre-war level.

Steel Sections.—Only a tabular statement can convey the remarkable movements in this class of material, which includes rods, bars and angles but not girders, beams, joists or pillars. The figures are for the seven months, January-July, in each of the five years :—

	Imports. Tons.	Exports. Tons.
1910	31,300	131,000
1913	103,000	159,000
1916	57,300	407,000
1917	29,900	245,000
1918	13,200	102,000

In this case our war exports greatly exceeded our pre-war exports, for a time. Apparently we had to supply France at all costs and are now doing so largely, perhaps with increased help from America. The same tendency is shown in the figures for steel ingots, billets, &c.

Machinery.—Our import of engines has practically remained at its small pre-war level, except in agricultural engines; electrical machines have decreased and machine tools have increased. Our large pre-war export of engines has gone down to a quarter, from 100,000 tons in 1913 to 25,000 tons in 1918 (both seven months). Our export of electrical machines has fallen to less than a half in the same periods. Many engineers may be surprised to know that our export of machine tools is substantially the same as before the war, and that in 1917 it was actually larger.

Iron and Steel Scrap Order.—The Minister of Munitions has issued an Order dated August 20 providing that every person owning iron or steel scrap (whether metal, machinery, plant or constructional steel or iron work), shall sell and transfer such scrap whenever required by the Controller and that the Controller's decision as to what is scrap shall be final. The Order further provides that if any such requirement to sell is not complied with within 30 days the Controller may sell or transfer the scrap, the owners in that event receiving the price realised less cost of sale. Owners are to give all reasonable facilities for removal of material and make such returns as may be required. All applications under this Order should be made to the Controller of Salvage and Stores, Ministry of Munitions, Whitehall-place, S.W. 1, and marked "Iron and Steel Scrap."

Iron and Steel Institute.—The autumn meeting of the Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, September 12 and 13, commencing at 10.30 a.m. on the 12th and at 10 a.m. on the 13th. On both days there are to be afternoon meetings commencing at 2.45. The following is the list of papers that are expected to be submitted :—1. C. H. F. Bagley: "Principles of Open Hearth Furnace Design." 2. E. D. Campbell: "The Rate of Change at 100 deg. C. and at Ordinary Temperatures in the Electrical Resistance of Hardened Steel." 3. H. C. H. Carpenter and C. Coldron Smith: "Some Experiments on the Reaction between Pure Carbon Monoxide and Pure Electrolytic Iron below the A1 Inversion." 4. G. Charpy: "Influences of Hot Working on the Qualities of Steel." 5. J. E. Fletcher: "The Casting of Steel in Ingot and other Moulds." 6. A. F. Hallimond: "Notes on a Telescopic Focussing Apparatus for Photomicrography." 7. D. Hanson and J. E. Hurst: "Case-Hardening Practice." 8. J. S. Hollings: "Use of Bosh Tuyeres in the Blowing of Basic Pig Iron." 9. K. Honda: "On Magnetic Analysis as a means of Studying the Structure of Iron Alloys." 10. J. E. Hurst: "Prevention of Growth in Grey Cast Iron." 11. Cosmo Johns: "Standardisation of Tests for Refractory Materials." 12. T. B. Mackenzie: "The Utilisation of Waste Heat from Open-Hearth Furnaces for the Generation of Steam." 13. A. McWilliam: "Influence of Elements on Tenacity of Basic Steel." 14. C. H. Ridsdale and N. D. Ridsdale: "Chemical Standards and their Bearing on the Unification of Analysis." 15. A. F. Shore: "Hardness Testing: Relation between Ball Hardness and Scleroscope Hardness." 16. J. H. Teng: "Phosphorus in Malleable Cast Iron." 17. J. H. Whiteley: "Notes on the Warping of Steel through Repeated Quenching."

TIN MINING IN THE FEDERATED MALAY STATES.

The present position of the metal market gives added interest to the section of the annual report of the Mines Department of the Federated Malay States dealing with tin mining in 1917. British territory produces by far the largest share of the world's supply of tin, and the Malay States for very many years have been the chief source of the metal. Last year's export from the Federated Malay States amounted to 39,833 tons, as compared with 43,870 tons in 1916, but the value of the exports rose from 7,526,566*l.* in 1916 to 8,489,610*l.* in 1917.

Commenting on the shrinkage, the Senior Warden of Mines (Mr. W. Eyre Kenny) writes :—"Opinions have been advanced with regard to the decline in output since 1913, the last pre-war year, attributing it to various causes; but there is one point that has been lost sight of which is that though the average price of tin as quoted on the Singapore Market for 1917 was 5.44 dols. per pikul higher than it was in 1913, costs had so increased that the margin of profit was smaller in the past year, and there is little doubt that this had an effect on diverting Chinese interest to other pursuits. The impossibility of obtaining capital and plant for new European ventures must have also had an effect, as the area of payable shallow or easily worked ground decreased year by year. It is not alleged that 1917 was not a profitable year for miners; but it is asserted that it was not sufficiently attractive to encourage fresh local ventures under war conditions." As nearly as can be ascertained, 71 per cent. of the total output was obtained from mines under Chinese management.

The average sterling value per ton in Singapore in 1917 was £213 2*s.* 7.3*d.* (a new record) compared with 171*l.* 11*s.* 2.1*d.* in 1916 and 153*l.* 4*s.* 3.1*d.* in 1915. In no previous year has the London market been subjected to such abnormal pulsations as in 1917, the lowest cash price quoted being 180*l.* 15*s.* on January 1 and the highest 309*l.* per ton on December 21—a fluctuation of 128*l.* 5*s.* per ton.

The output and value of the four States is compared in the following table :—

	1916.	1916.	1917.	1917.
	Tons.	£	Tons.	£
Perak	27,242	4,675,379	24,643	5,264,215
Selangor	12,241	2,099,072	10,960	2,323,541
Negri Sembilam ..	907	155,887	734	157,346
Pahang	3,480	596,228	3,496	744,508
Total	43,870	7,526,566	39,833	8,489,610

The total labour force at the end of the year was 123,340, all of whom, with the exception of 1,017 on gold and 700 on coal, were employed on tin and tungsten mining, against 139,143 in 1916 and 164,457 in 1915. Of the miners, 117,015 were Chinese, 4,289 Indians, and 1,774 Malays. There were 181 Europeans employed in supervision at the mines.

In the previous year, a substantial increase was shown in the use of modern machinery at the mines, but in 1917, probably on account of the difficulty of obtaining machinery from England and Australia, there was a falling off in horse-power. The only new plant of any magnitude installed during the year was the Tin Bentong Company's hydro-electric power plant and electrically operated dredge. The following table of horse-power shows the nature of the machinery and appliances in use in the Federated Malay States mines :—

	1916.	1917.
Steam	24,810	23,748
Steam-electric	4,255	2,420
Hydraulic	17,911	18,524
Hydro-electric	3,540	4,395
Suction gas	2,203	1,794
Oil engines	3,851	2,692
Oil electric	1,495	2,003
	58,074	55,576

Taking the local average of eight labourers per horse-power, it will be seen that the aggregate in 1917 was equal to a labour figure of 444,608 against 464,592 in 1916.

University of Bristol.—Faculty of Engineering.—We have received a copy of the prospectus of the Merchant Venturers' Technical College, which provides and maintains the above-named faculty, from which we note that the courses include schemes of study for persons intending to engage in civil, mechanical or electrical engineering. The department of automobile engineering has been closed for the duration of war, as the professor of that Department is doing important work in connection with munitions.

Cast-Iron Scrap Order.—The Minister of Munitions has issued an Order dated August 20 controlling Cast-Iron Scrap and making an addition to the General Permit dated November 1, 1916, fixing maximum prices for various grades of that material. Certain additions to and modifications of the general permit dated November 1, 1916, and subsequent modifications thereof dated March 22, 1917, and January 4, 1918, relating to second-hand rails and wrought iron scrap are also made. All communications in reference to the Order and modification of permit should be addressed to: The Controller of Iron and Steel Production, Room 101, Ministry of Munitions, 8, Northumberland Avenue, W.C.2.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—The incessant activity in the steel trade continues and increases, and makers are as well booked up with orders as they have been at any period during the past four years. Unfortunately the present serious outlook in the coal trade threatens some considerable trouble in the immediate future, unless drastic measures are taken without delay to speed-up the output and improve the conditions of transport. The extension and enlargement of premises and plant put through during the holidays are already telling a tale of increased output, every endeavour being made to maintain this and so wipe out some at least of the accumulated arrears. Steel plates and sections and steel bars for shells constitute a particularly heavy part of the output, while repair work on Admiralty account is likewise a considerable item.

Malleable Iron Trade.—It is a significant fact in connection with the malleable iron trade that, notwithstanding the recent advance of 17*s.* 6*d.* per ton there has been no falling-off in the way of business, the home demand being as brisk as ever and orders still pouring in as if nothing untoward had taken place. Indeed, makers invariably report increasing activity, everything produced being rapidly absorbed on home account, and it being quite evident therefore that where the material is required price is of little moment. "Crown" bars for export are still quoted at, or about, 16*l.* 5*s.* per ton.

Scotch Pig-Iron Trade.—Like other associated branches of industry, the pig-iron trade keeps forging ahead, the only barrier to an even largely augmented output being the difficulty of obtaining greater supplies of raw material. The demand is very heavy, all grades being much in request, with hematite still topping the list. Some brands are rather scarce, foundry notably so at the moment, every available ton being diverted to work of national importance. As in all other industries the present condition of the coal trade is causing much anxiety to the iron smelters in the district. No change in the price of pig-iron has yet been intimated.

Ironmoulders' Wages.—An award has just been made by the Committee on Production relative to the recent application made on behalf of the ironmoulders employed by the firms composing the National Light Castings Ironfounders' Federation. When the case for the ironmoulders of Scotland was heard some little time ago, the Federation was unable to arrange for representation, so that the employees missed sharing in the benefits then obtained. Their claims have now been favourably considered, with the result that an advance of 3*s.* 6*d.* per week has been allowed to both time and piece workers, the award to take effect as from the week ended August 10, as in the other case.

Shipbuilding Prospects: Erratum.—Through a printers' error, introduced after the final proof was passed, the word "indefensible" was substituted for "indefeasible" in the paragraph on page 177, column 1, line 14, of our last issue. The line should read, "From the logical standpoint this attitude may be indefeasible." The alteration of a single letter thus reversed the whole meaning of the words.

Rapid Ship Construction.—Messrs. Harland and Wolff, who hold the United Kingdom record for building oil carrying vessels of 6,000 tons (standard type), did a smart bit of work with their fifth vessel of that class. After the ship was launched, the engines and boilers were put on board within one working day. Four weeks later, it is expected, her fitting out will be complete. In the meantime another "record" is in process. The keel has been laid of a sixth vessel of this type, to be completed within 21 weeks—before Christmas.

Trade with China.—Mr. Thomas N. Sammons, the United States Consul-General at Shanghai, who is at present at home on vacation, has been telling his countrymen, says *The London and China Telegraph*, of the great opportunities which exist for the extension of trade in China. His advice might well be taken to heart by British merchants and manufacturers engaged in business with that country. He advocates the sending of first-class men to China to study local trade conditions, and he somewhat quaintly remarks "they must secure converts to our industrial interests, just as the American missionary secures and holds converts to the Christian faith." The missionary masters the language and local customs, and a considerable proportion of business men should go prepared to do likewise. Mr. Sammons mentioned that British traders, with a slight falling-off of their population in China, due to the war, have increased the number of firms to 655. But there are 7,000 foreign firms in China, an increase of 2,350 over 1916. Russia increased its number in 1917 by about 1,500, and Japan by 1,000. At Shanghai the Japanese have many powerful commercial houses, and the Russian Bank building is among the most imposing structures in the Far East. In banks, as well as commercial houses, Japan is advancing, having as many banking institutions there as all other foreigners combined. The Consul-General evidently has great faith in the future of China and her trade, which undoubtedly offers plenty of scope, not only to the manufacturers of America, but also to those of all other nations desirous of cultivating or extending business relations with that great Far Eastern country.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—There is little that is new to remark in the situation. One or two departments continue to work under great pressure, but generally speaking, trade is of a somewhat restricted character. In the crucible steel line, the quietness that has been apparent for some time is as marked as ever. It is felt that the output from the furnaces would rapidly increase if there were fewer restrictions imposed on makers from official quarters. There is a fairly strong demand at home for this class of material, to say nothing of tonnage which might go overseas if shipping and other handicaps did not exist. Current orders are largely being met, however, from big stocks of crucible steel which have accumulated. The position, almost needless to say, is hitting the small makers rather hardly. Operations in the rolling mills are being hampered through the lack of labour. There is not the demand on the mills that formerly existed, but even now, the scarcity of labour is affecting allied branches of trade by causing delays in the rolling of material. Very little business is being done in Swedish iron and steel. There is no longer any difficulty in meeting the demand for alloy steel. One can now detect a slackening in the pressure for pig-iron, and the scrap supply is not nearly so troublesome as it was a short time ago.

South Yorkshire Coal Trade.—At the moment of writing there is unfortunately, the prospect of a further and what may turn out to be a very serious accentuation of the difficulties already existing in the coal trade. Miners in South Yorkshire have tendered notices to cease work on Thursday, in consequence of a dispute regarding hours. The matter has been the subject of negotiations and conferences for some time, and while it is hoped that at the last minute a settlement will be effected, the chances of such an event are not very great. The pressure for supplies continues strong in all departments. Best steams are urgently required by all classes of home consumers, and big quantities for export are being asked for. Cobbles, nuts and slacks are entirely absorbed by contract business; and in the household section, the shortage is still very marked. Cokes are difficult to obtain at top prices. Quotations:—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

PERSONAL.—Messrs. John I. Thornycroft and Co., Limited, shipbuilders and engineers, have notified us that, in consequence of the Government having commandeered their offices at Caxton-house, Westminster, they are removing to new offices at 10, Grosvenor-place, London, S.W.1. The new offices are quite close to Hyde Park Corner Station, Piccadilly Tube.

THE MERCANTILE YEAR BOOK.—The Mercantile Year Book and Directory of Exporters for 1918, the thirty-second annual edition, is now available. It is edited by Walter Lindley-Jones, F.R.G.S., editor of *The Mercantile Guardian*, and is issued by Lindley-Jones and Brothers, 16, St. Helens Place, E.C. 3, at the price of 15*s.* It covers London, Manchester, Liverpool and the other important British trade centres, for all of which the name of the British firm, the class of goods shipped and the market are stated. In the case of colonial and foreign firms, the name and address of the latter is given, together with the class of goods imported and the name of the buying agent. There are several directories arranged alphabetically as per names of merchant firms and as to goods dealt with. The book has over 700 pages of useful information both for British exporters and colonial and foreign importers. In sending us a copy of the present issue, the editor states that it has been produced under conditions of great difficulty caused by a depleted staff, shortage of paper, printing delays and his own voluntary work as Chief Organiser of the Department of the Controller of Paper, in connection with the collection of paper-making materials.

FERRO-CONCRETE SHIPBUILDING AT SINGAPORE.—The first reinforced concrete boat built in the Far East will shortly be launched at Tanjong Rhu, where most concrete vessels will be constructed, says the *Singapore Free Press*. This boat is built to answer the somewhat special conditions of a ferry boat. It will be used by the Federated Malay States Railways in the Johore States for conveying goods wagons across to Johore. At present this service is assured by steel ferry boats. The scarcity of steel, however, made it imperative to adopt some other material; wood was rejected, the preference being given to reinforced concrete. The dimensions of the boat are: Length, 125 ft.; beam, 27 ft.; and moulded depth, 8 ft., the gross displacement being 500 tons. It has the shape of the existing steel ferries, and carries all the machinery necessary for the handling of the wagons, steering, &c. The construction has taken about five months, and proved very successful from the beginning. The boat will have to stand fairly heavy work, and for this reason it has been designed on conservative lines. It is expected that concrete boats have come to Singapore to stay, and earn as good a reputation as the land ferro-concrete constructions now possess. Messrs. Brossard, Mopin & Co., the designers and builders of this ferry boat, are also actively engaged in the construction of a large sea-going motor vessel of 2,500 tons deadweight.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—With blast furnaces in operation whilst foundries, engineering shops, and steelworks are closed this week for the local annual holidays, a larger supply of pig-iron is available for despatch to other districts. Demand, however, is such that all the pig-iron that can be handled is still promptly taken up, and makers experience difficulty in finding sufficient labour to load the iron at the various works. Deliveries of Cleveland foundry iron under the monthly allocation system, are again somewhat in arrears. Exports are reported on a satisfactory scale, but as merchants are excluded from the French and Italian trade, which is conducted through official channels, their interest in sea-borne transactions is practically confined to shipments to Scotland, and other coastwise ports. Increasing use is being made of tonnage for coastwise despatch, and thus the congestion on the railways is being to some extent relieved. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge all stand at 95*s.*; and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and 1 lower qualities are 119*s.*; and No. 1 is 124*s.*

Hematite Iron.—Demand for East Coast hematite continues heavy. Every effort is made to maintain exports to the Allies, and this can only be accomplished by the most careful distribution to home customers, whose essential needs, however, are still receiving adequate attention. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for shipment to France and Italy, exports being through official channels, with the exception of one or two outstanding licenses which are being honoured.

Manufactured Iron and Steel.—Suspension of operations, for the holidays, at the finished iron and steel works, is enabling manufacturers to carry out very necessary overhauling of plant, and to execute much-needed repairs and renewals, which it is hoped and believed will be reflected in increased output. Production of all shipbuilding material is well in hand, and, indeed, at some of the works, even greater output of work of this description might have been possible recently. Prices are very strong. To home customers common iron bars are 14*l.* 15*s.*, best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; triple best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export quotations may be given as approximately 2*l.* to 3*l.* above home prices.

Coke.—The situation as regards coke is unsatisfactory and embarrassing. So great is the shortage that absolute needs of the blast-furnaces are very difficult to meet, and there appears little likelihood of any material improvement in the near future. Average furnace coke is 33*s.* at the ovens; and low phosphorus quality 35*s.* 6*d.* at the ovens. Inquiry on behalf of neutrals is as insistent as ever and 65*s.* f.o.b. is offered freely for foundry coke, but such business is practically impossible with requirements in other directions so urgent.

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of iron bars and angles for the two months ended June 30 last at 14*l.* 2*s.* 8·62*d.*, as compared with 14*l.* 1*s.* 9·54*d.* for the previous two months, and according to sliding scale arrangements ironworkers' wages for August and September remain the same as prevailed during the preceding two months. In accordance with the instructions contained in a letter dated April 16, 1918, from the Ministry of Munitions, the average realised price for the period ended June 30 should be increased in respect of subsidies granted to pig-iron makers, by the sum of 20*s.* per ton on sales for home consumption. After making this adjustment the ascertainment is increased to 15*l.* 2*s.* 2·97*d.* per ton.

BRITISH AND FRENCH CIVIL ENGINEERS.—The journal of the Société des Ingénieurs Civils de France, in giving an account of the centenary of the British Institution of Civil Engineers, states that the term "civil engineer" is used in this country to differentiate from the military engineer, the one who occupies a situation corresponding to the French Engineer of Roads and Bridges, or the French Municipal Engineer; whilst in France the term is used to denote more especially the engineer who practises on his own account, as distinguished from the engineer who occupies an appointment under the State.

SHIPBUILDING IN SWEDEN.—The Helsingborg Shipyard has applied for permission to fill up an area in the harbour, between the dock pier and the Western harbour quay, so as to be enabled to build vessels up to 3,000 tons, an extension which the shipping circles of the town consider very desirable, and which the harbour authorities recommend. The large Swedish Trading and Shipping Company has placed an order for an 8,000-ton boat with the Oresund yard, to be delivered by June next year. The company contemplates ordering three or four more boats of the same type and size. The first order was to replace five older vessels of 1,500 tons each, which the company has just sold to the Broström shipping concern and the Baltic Company; the new owners will place these boats on certain routes where the war risk is exceptionally great. They do not want to jeopardise larger and new vessels in their trade.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The outstanding feature of the markets at the present moment is the extraordinary shortage of pretty well all classes of coals. All available stocks have been cleared away, and the railway sidings have been denuded even of the small coals of which not so very long ago there was such a glut of supplies. Salesmen during the last fortnight have experienced a harassing time. Pressing orders have been accumulating, but requirements, except the most urgent and pressing, have been unsatisfied. Following the holidays, the men did not return to work in full numbers, and the output last week was considerably below the normal. Reports from the colliery districts this week show an improvement as far as the attendance of men at work is concerned, but production, unfortunately, does not show a corresponding improvement. In some cases, it is true, it is more favourable than a week ago, but it was estimated to-day that the average outputs are still 15 per cent. to 20 per cent. below those of normal pre-war times. The percentage of workmen withdrawn for the military is not so great as this, and the difference still suggests avoidable, if not culpable slack working. For certain regrettable reasons tipping operations at the Bute Docks have been almost entirely suspended, and in these circumstances shipments have been still further curtailed, and the number of vessels now awaiting cargo is very large. Although salesmen are finding it extremely difficult to obtain the release of their coals for private trading, they are quoting prices much in excess of the scheduled figures for neutrals, the difference in some cases amounting to about 10*s.* per ton.

Newport.—From the Monmouthshire coalfield there are reported slightly improved outputs, and the quantity of coal allocated for shipment is, therefore, increased. The demands of the Admiralty and the Allies, however, leave hardly any coal free for export on private account, and contracts are heavily in arrear. Although supplies for inland consumption are restricted they are not adequate for the immediate requirements of railways, factories, and public utility purposes, and no case of an actual stoppage of work through an insufficient supply of fuel has been reported. This has been largely due to the care exercised by the District Coal and Coke Supplies Committee in the distribution of available coals.

South Wales Coal Trimmers' War Bonus.—The coal trimmers in the Bristol Channel ports made an application for an increase of the war bonus to 100 per cent. They had already had an increase of 60 per cent., and the new demand, therefore, was for an additional 40 per cent. The Central Trimming Board met yesterday to consider the matter, and the employers' and workmen's representatives arrived at a compromise by the granting of an advance of 20 per cent. as from Monday next, bringing the war bonus up to 80 per cent.

Colliery Surfacemen's Hours.—At a conference of delegates of the South Wales Miners' Federation held at Cardiff on Monday, it was resolved to press upon the coal-owners for an immediate reduction in the hours worked by colliery surfacemen to eight hours per day. In the event of this concession not being granted by the coal-owners the Executive Council of the Federation were instructed to approach the Coal Controller on the matter. It may be taken for granted that in these days when there is such a shortage of labour the owners will not readily agree to a curtailment of the hours of working, and at this juncture the new demand is certainly inopportune.

SLAG CONCRETE FOR SHIPS.—Particulars are given in *The Iron Age*, New York, of a number of tests carried out with various classes of concrete, the conclusions of which are the following, comparison being made with crushed stone concrete:—Slag concrete has 27 per cent. greater compressive strength; it weighs 17½ per cent. less; it has 20 per cent. higher bond strength; and 40 per cent. higher resistance to impact.

NON-FERROUS METAL INDUSTRY ACT, 1918.—With reference to a notice that appeared in *The Board of Trade Journal* and in our issue of the 2nd inst. (page 115 *ante*) respecting the issue of licences under the above Act, the Board of Trade desire to make it clear that applications for licences may be made at any time and will be considered in the order in which they are received. But the extension of time referred to in the above-mentioned notice, allowing persons to continue to trade without licence, applies only to those whose applications had been received by August 5. Persons making application after that date will not be able to carry on business as defined in the rules in the metals and ores to which the Act applies unless and until they have received a licence.

DISTURBANCE OF A REFRIGERATOR BY GREASE.—A case of serious disturbance of a sulphur dioxide refrigerator was recently reported in the *Zeitschrift für die Gesammte Kälte Industrie*. The material had been working for several years, when the piston-rod of the cylinder became corroded, and the stuffing-box did not keep tight. Bacon had been used as lubricant, and the grease gained access into the cylinder, and finally into one of the distributor coils, which the freezing grease blocked completely. The deposit became so hard that it could only be removed with the chisel and drill after burning holes into the tubes. The tubes were afterwards welded again. The service was not long disturbed, but the expense was considerable. It is hence recommended to examine the piston-rods frequently to avoid similar occurrences, but the primary cause of the accident is not sufficiently explained by the details given in the journal mentioned.

MULTIPLE EFFECT COMPRESSION ICE-MAKING AND REFRIGERATING MACHINE.

CONSTRUCTED BY MESSRS. SEAGERS, LIMITED, ENGINEERS, DARTFORD, KENT.

(*For Description, see Page* 201.)

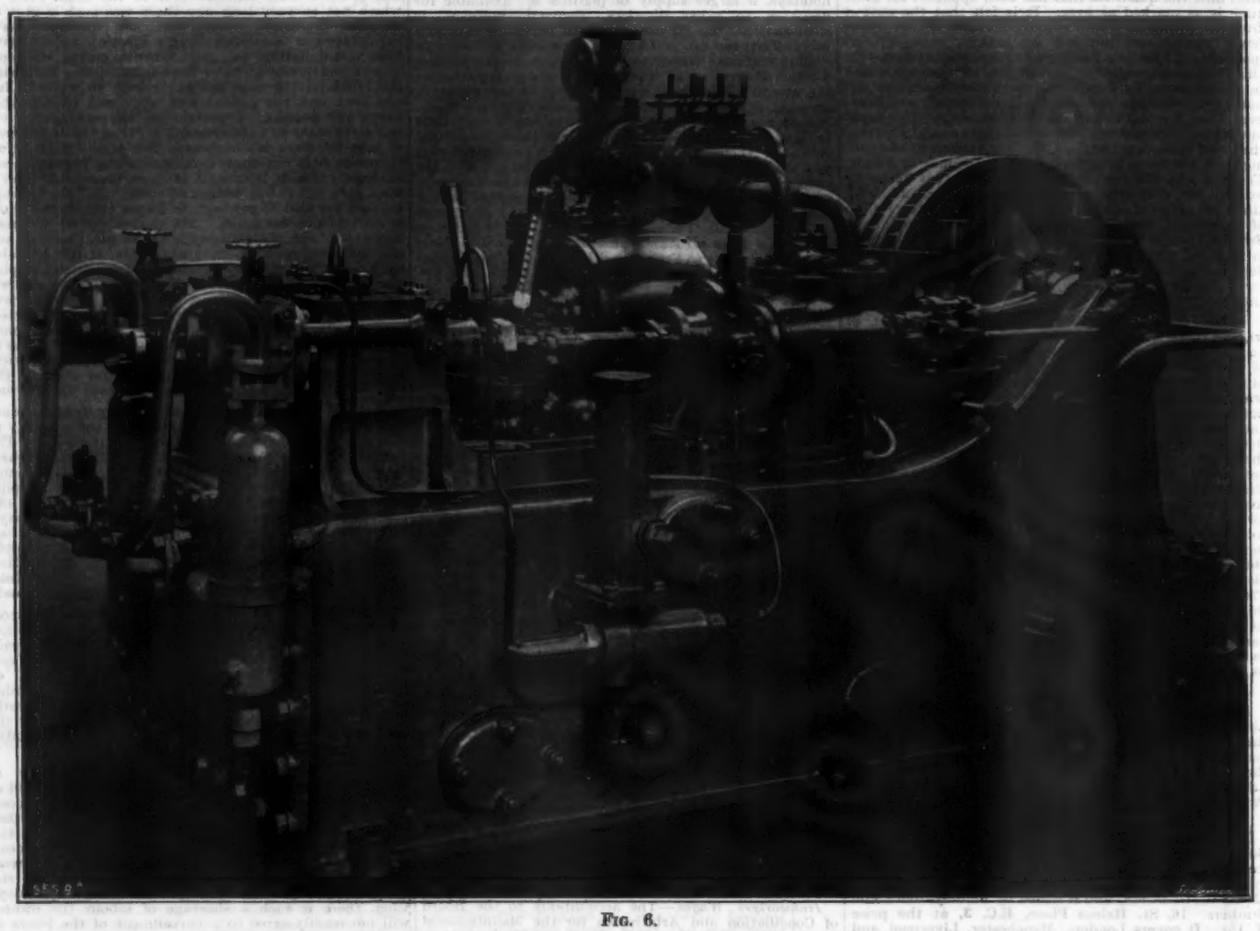


Fig. 6.

New Dry Dock for San Francisco.—A large dry dock is nearing completion at Hunters' Point, South San Francisco. The dock, which is 1,050 ft. long, will be able to accommodate any vessel afloat, and is described as the largest in the world. Powerful electrical pumping machinery has been provided by the Westinghouse and General Electric Companies, and in every respect the equipment is believed to be of the most modern and efficient type. The United States Shipping authorities realise that with the provision of a huge mercantile marine the construction of dry docks will be essential. At present the supply seems fully equal to the demand; dry docks on the Atlantic Coast are employed as construction basins for new tonnage. In these work proceeds on an even keel and no launching takes place, the water being simply pumped into the dock and the vessel floated out.

National Motor Vehicle Depot.—The Committee on National Expenditure has reported in favour of the proposed Motor Transport Depot (Warehouse and Repair Works) at Slough. The motors now awaiting repair in England are stated to be "several thousand" and "three times as many as a year ago." An almost equal number are waiting in France. Altogether "they represent some millions of pounds worth of plant lying idle." The spare parts number 200,000, valued at 6,750,000*l.*, and are so stored in scattered places that there is involved "a waste of money, of labour, of transport and of time." The committee also complains of "new lorries and cars being manufactured and brought into use, while serviceable vehicles, needing only a fraction of the labour to be put into order, are standing idle in thousands." The cost of the new depot is estimated at "somewhat over a million pounds." It is to be built in sections, each to be completed for use as soon as possible. The committee considered whether arrangements could be made with each manufacturer to repair his own make of vehicles, but "for various reasons, into which it is not necessary to enter in detail, they are convinced that there is no satisfactory alternative to the establishment of a central depot." It would be interesting to know the reasons against repairing the vehicles in the works where they were built; none at all are given.

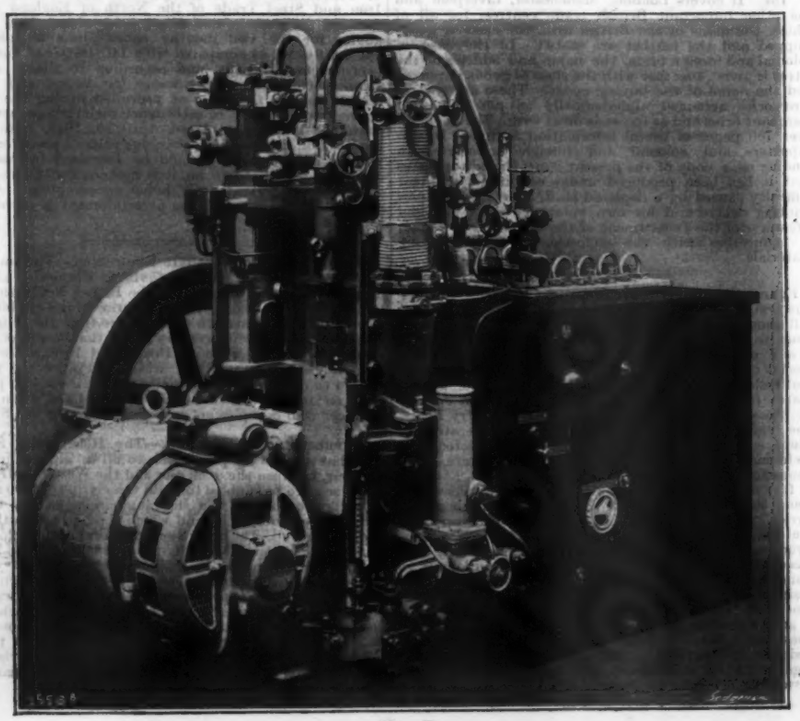


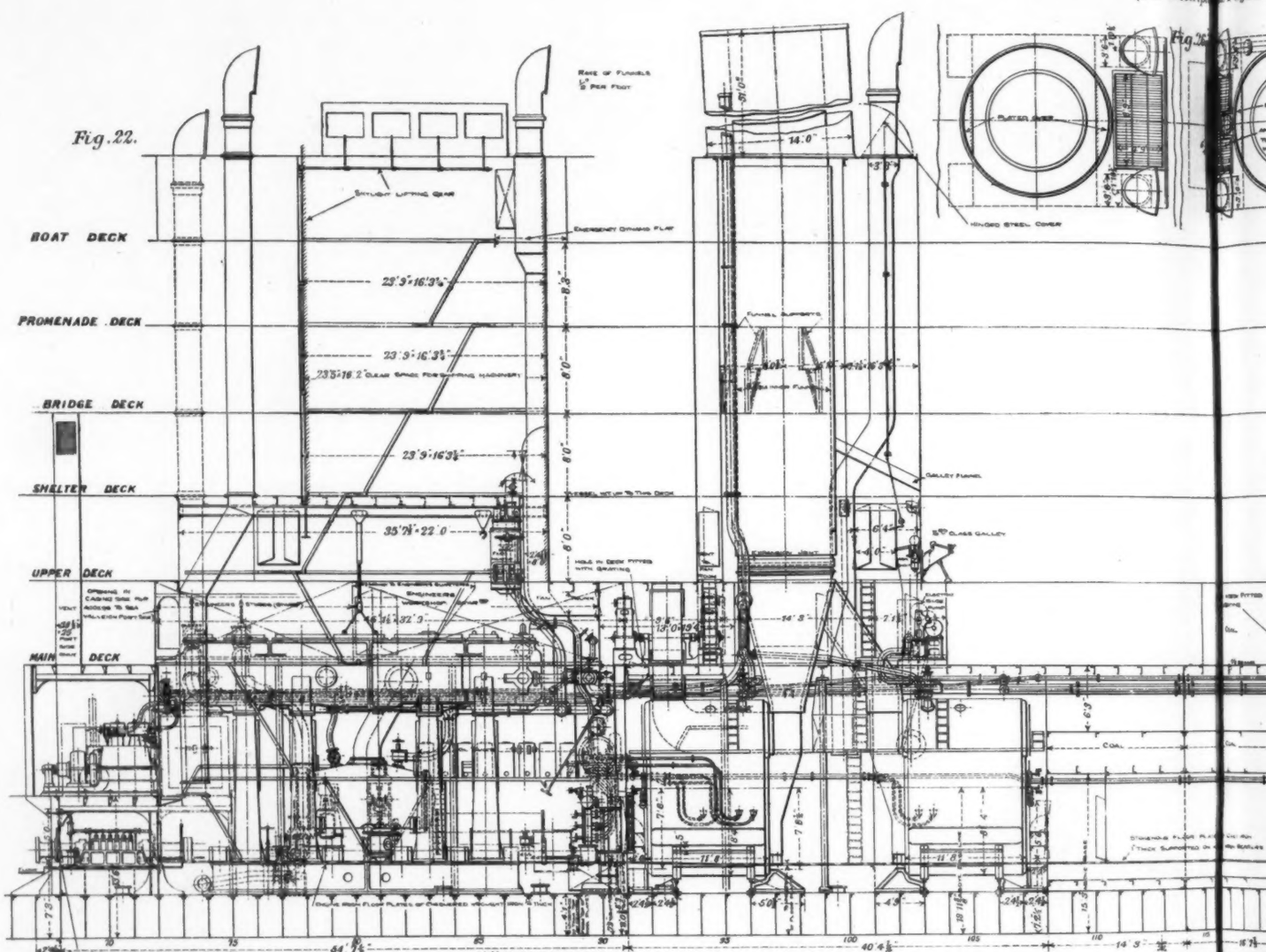
Fig. 7.

ARRANGEMENT OF MACHINERY FOR THE T.S.S. "JAVA

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO. LIMITED,

(For Description, see Page 20

Fig. 22.



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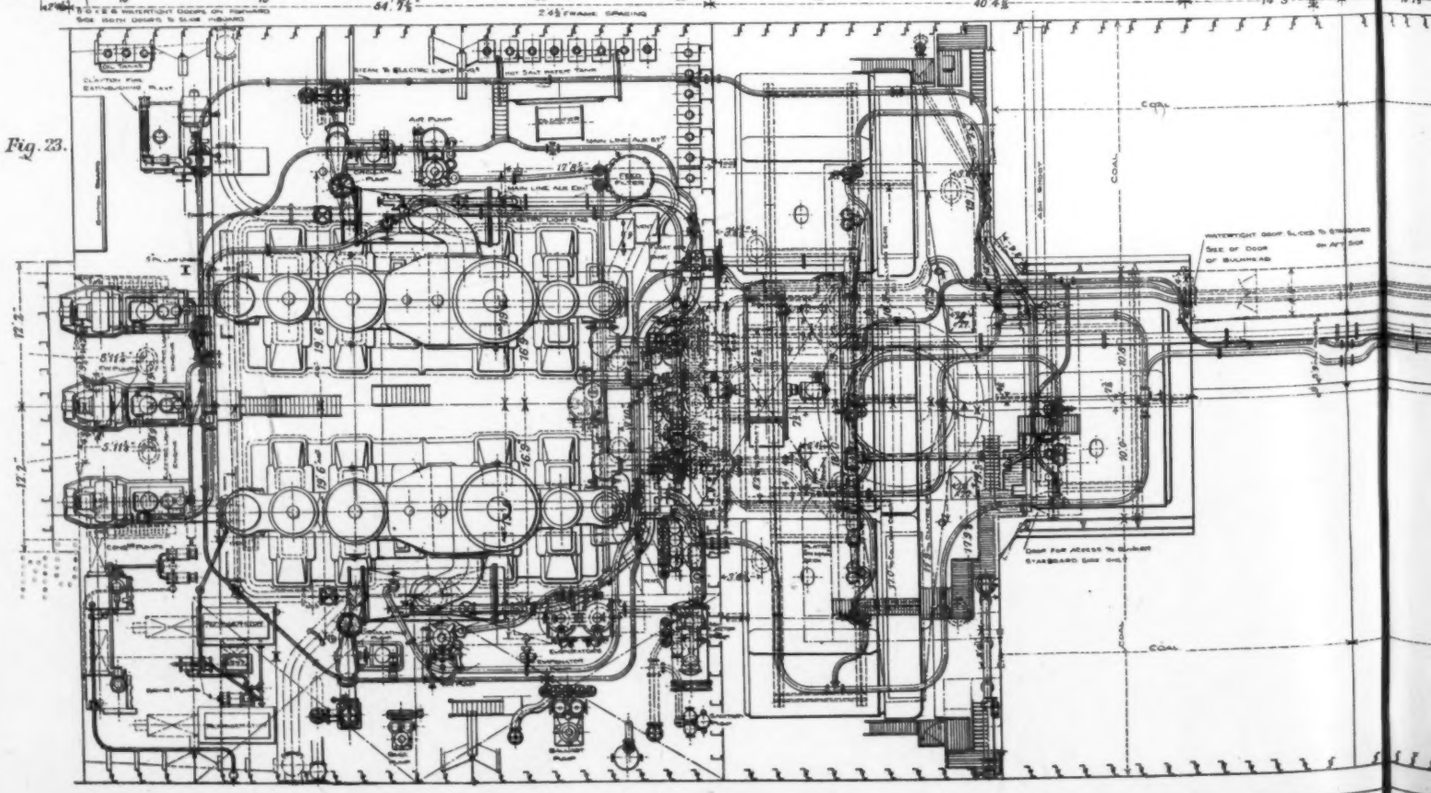

"STAVANGERFJORD" OF DET NORSKE AMERIKALINJE.

CO[illegible]MITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

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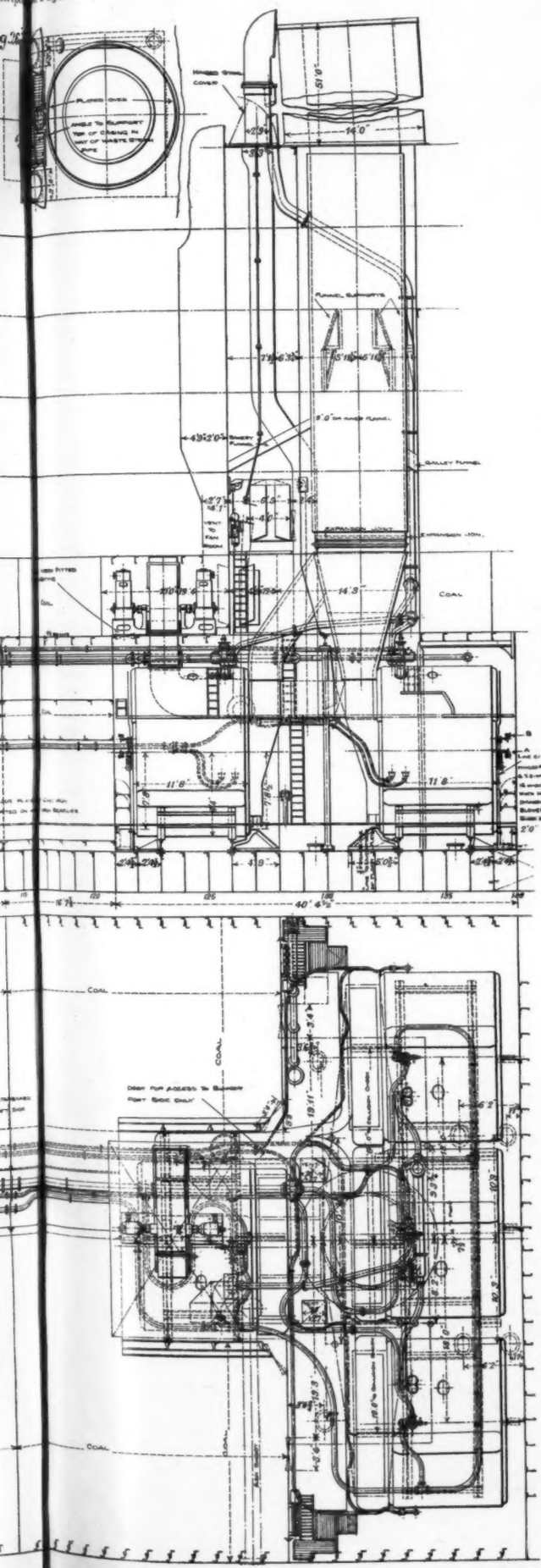
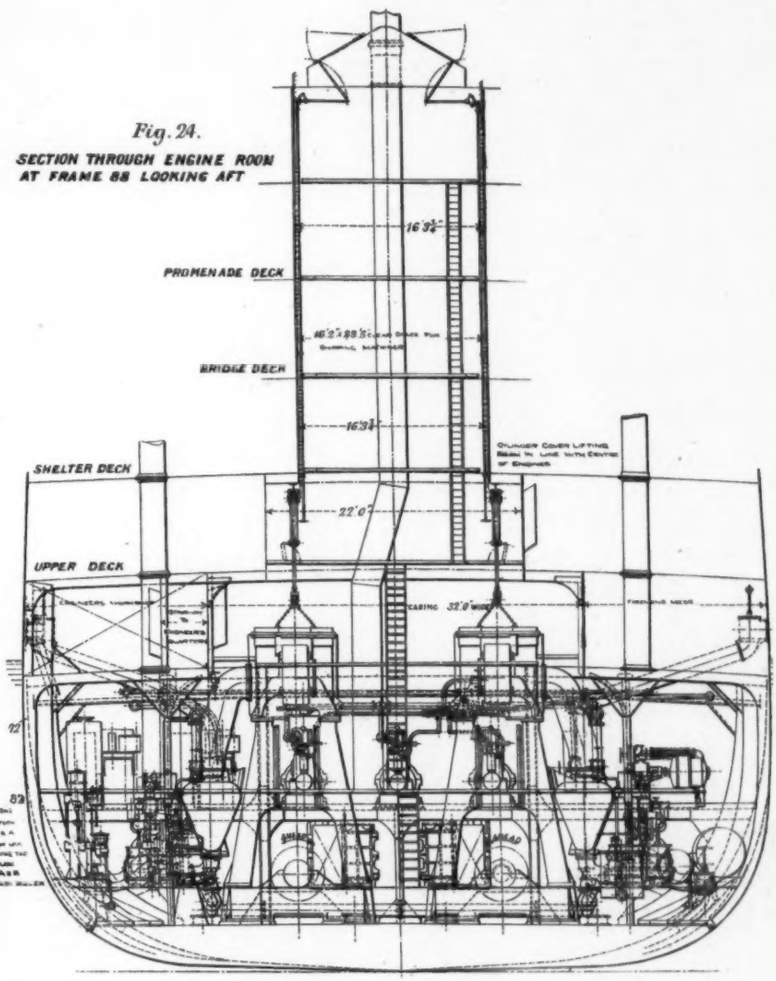


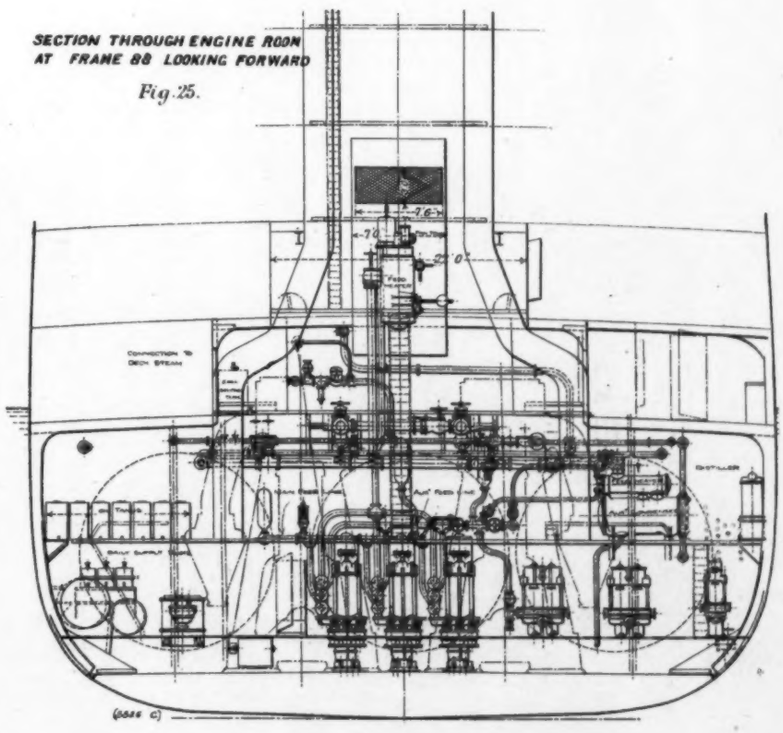
Fig. 24.

SECTION THROUGH ENGINE ROOM AT FRAME 88 LOOKING AFT



SECTION THROUGH ENGINE ROOM AT FRAME 88 LOOKING FORWARD

Fig. 25.



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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8593 GERRARD.

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With a Two-Page Plate of the ARRANGEMENT OF MACHINERY FOR THE T.S.S. "STAVANGERFJORD" OF DET NORSKE AMERIKALINJE.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 23, 1918.

LABOUR AND THE LABOUR PARTY.

THE Labour Party in Parliament profess to be the representatives of labour in the country, and particularly of organised labour. But when they have proposed, or agreed to, a certain course of action, it often occurs that labour repudiates them and all their works. It is thus rendered evident that there is a rift between the leaders and those who are supposed to be led, with the result that the employer is embittered against them both. The chief cause is that labour leaders have tried to be trade union officials and politicians at one and the same time, and they have failed to the extent that the rank and file no longer trust them, or follow them, and trade union indiscipline is the result. The shop stewards movement is the outward and visible sign of an inward and spiritual revolt against the political trade union leader. To understand the position clearly it is necessary to take a glance backward. From about the eighteen seventies to the beginning of the present century, trade unionism steadily became more disciplined, voluntary conciliation grew, and strikes declined. Wages rose more rapidly than food prices, and labour advanced both absolutely and relatively. The right of collective bargaining was won and recognised, and employers became more and more tolerant of trade unions. Boards were set up in all the big industries, and agreements were generally observed. All that happened, be it noted, before there was a Labour Party. But since so many Labour leaders have dabbled in politics, whilst still retaining their positions as union officials, they have got out of touch with actual workshop conditions, and do not now fully understand the ever-changing processes. They make poor negotiators when called from London to settle some shop trouble, their agreements often turn out badly, and as these leaders are strangers to the workmen the latter have come to distrust them.

Again, whilst the men who should be the real leaders are most of their time at Westminster, hot-headed and irresponsible young men of Socialistic ideas, men barely out of their apprenticeships, usurp the management of the branches. Moreover, the very fact of the official leader declaring his political opinions, and entering into public movements of sharp controversy, offends a minority, and sometimes a majority, of the members. Among trade unionists, as in other classes, there are men of all political views and religious sentiments, and no matter what the political leader may do he is bound to dissatisfy some of those whose interests he is supposed to represent. The leaders have lost their influence and authority because they have become orthodox politicians without resigning their officerships.

When the trade unions were induced to support the Labour Party they were promised great things. These have not materialised. Whereas, prior to the advent of the Labour Party, wages for instance went up in advance of food prices, they have failed to do so since. In the last fifteen years before the war food prices rose twice as fast as wages, which was the very opposite of what happened before 1900 or thereabouts. The Labour politicians supported socialistic financial measures, and, of course, real labour suffered.

The politicalisation of the unions has also had a bad effect on the employers. In the labour leader of to-day the employers recognise not merely an agent of the workmen honestly trying to secure better industrial conditions, but in many instances also an active political enemy advancing measures and movements to harass industry, tax enterprise, and make it more and more difficult to meet the demands of labour. Thus the employers and their managers become inclined to drive hard bargains, and finding the Westminster delegate unacquainted with the technicalities of industry, they sometimes "catch him napping," to the detriment of the men, whilst when, as so often happens now-a-days, Government officials come into the business there is bound to be trouble.

Thus it comes about that we see labour conditions being revolutionised. The shop stewards movement aims at getting back to something like first principles. This movement, if treated with the proper blend of sympathy and firmness will not prove the danger commonly supposed. It is a quite intelligible movement to get back to the settlement of disputes on the spot, where they arise, and by the parties primarily concerned. It may not, as a rule, be very well expressed or conducted, and it may be too largely run by young hot-heads, but in its essence it is a revolt against political labour misleadership.

The Labour Party have great influence with the Government and particularly with the Ministry of Munitions. No important step is taken without consultation with them, and indeed the difference of the treatment meted out to them compared with that extended to manufacturers is most noticeable. Yet in spite of their assistance the Ministry has mismanaged wages in a striking way. In many cases unskilled men, some of whom had never been inside a workshop before the war, have been drawing excessive wages, for simple repetition piece work, whilst the mechanics have been kept on time work, earning only the standard rates, plus bonuses. These regular men have to do all the delicate and difficult jobs, fixing and gearing the machines and setting the tools for low wages, to enable the novices to get the high wages.

The question of promotion has also been badly managed under the Munitions Act. Since the war started there has been vast expenditure of capital resulting in a huge extension of productive capacity. Old works have been extended and many new ones have been built. There have been many vacancies for managers and foremen. But skilled engineers have been prevented from obtaining these posts. They have been kept at the drudgery, and low wages, whilst ex-grocers and barbers and even parsons have been appointed to the better positions. This policy has promoted neither efficiency nor contentment. The Munitions Act irritated the workers from the beginning. It was drafted by the same school that brought Prussian compulsory insurance to this country. Not only was it laid down in the stiffest of official language that every workman must attend regularly, work diligently, keep sober, obey all orders, and take no part in any disturbance, but, not satisfied with the parade of these regulations, the Ministry of Munitions actually advised the employers to bring to the special notice of the workmen their own obsolete shop rules for enforcing discipline.

The politician, to whatever party he belongs, wants votes. They are the life blood of his existence, and to the necessity of gaining them he must sacrifice his sanest principles, or else imperil his political career. The Labour member is in a specially difficult position. He has not only to satisfy his constituency, like any other member, but he has also to appear to lead his union, and at the same time to gain a reputation in the House for sincerity and straight dealing. As a rule he is a man of intelligence and probity and takes a reasonable view of any matter brought before him. He can retain the confidence of his constituency who judge him from his political actions, and who embrace men of various trades and occupations. But with his

union the case is different. As we have said he is apt to get out of touch with them, first because his time is occupied at Westminster, and secondly because he becomes accustomed to a broader and more cultured atmosphere in which the prosperity of the nation, or of the empire, replaces the material interests of the members of a single trade. Hence, we continually see the valuable, and often noble and patriotic advice of the Labour member openly flouted by those for whom he professes to speak. The result is that the union, which in theory is a disciplined body, becomes a rabble following any one who is able to secure the temporary leadership.

It is quite right that Labour should be represented in Parliament by men of its own class. There have been several such who have added dignity and value to the proceedings at Westminster, and who have won golden opinions from their fellow members on both sides of the House. But the stress of war has shown how incompatible is their position when they attempt to double the role of the politician and the trade union official, and it would be well if we could revert to the old position when the unions were administered by men in daily contact with the trade with which they are affiliated, and having no claims which are incompatible with the best interests of the union.

BY-PRODUCT RECOVERY IN IRON AND STEEL WORKS.

Bearing in mind the very interesting investigations which are being carried out by the committees of the Iron and Steel Institute, among others, those for steel manufacture and for blast furnace practice, particulars of whose work we have given in preceding issues, it appears to us interesting to place on record the substance of a paper read at the Congrès du Génie Civil, held in Paris in March last, by Mr. A. Gouvy, the well-known French metallurgist. In his communication, Mr. Gouvy deals with the utilisation of the gases and other by-products of iron and steel works, and states that the economic manufacture of iron and steel not only depends upon the raw materials available, but also upon a judicious combination of their utilisation with the recovery of all by-products. According to him, an essential condition for the utilisation of these by-products is to do away with certain practices based upon methods of working which are more or less empirical, theory being called upon without exaggeration nor exclusiveness to play, in aid of actual practice, a more important part than has hitherto been the case. The subjects dealt with are classified under three headings, coke ovens, blast furnaces and steel works, and we review in the present article the points which seem to us the most important.

The recovery of coke-oven by-products has been solved for several years past; their selling price before the war was at least 2s. per ton of coal treated, which would mean a saving of 10,000*l.* per year for an iron works using 100,000 tons of coke annually for the manufacture of coke.

In the course of a recent stay he made in Russia, Mr. Gouvy was able to ascertain the very great advantages derived from the use of naphtha in metallurgical furnaces; he was thus led to recognise the interest which would attend the development in France of the use of heavy oils obtained from the distillation of tar, these oils having a great analogy to naphtha. The question of the heavy oils was taken up in Germany as early as 1910, and following an active propaganda, the coke ovens were made to yield 1,000,000 tons of tar in 1911, from which 300,000 tons of heavy oil were extracted.

This oil is fluid at + 15 deg. C.; on cooling down to freezing point, a deposit of naphthalene is formed which is re-dissolved when heated by means of a coil. The specific gravity of the oil is from 1 to 1.1; its calorific value from 8,850 kg. to 9,000 kg. calories (about 16,000 British thermal units per lb.), and above, according to the hydrocarbons (naphthalene) it contains. The percentage of sulphur is only from .3 per cent. to .5 per cent., and rarely reaches .7 per cent. The flash point is between 65 deg. C. and 90 deg. C., and the oil burns without leaving any residues. These oils were sold in 1911 by the Deutsche Teerprodukten Vereinigung at from 4 marks to 5·50 marks per 100 kilos (40*s.* to 55*s.* per ton). Tar oil is used in Diesel engines, in which the consumption is from 200 gr. to 225 gr. (less than ½ lb.) per h.p. hour, but Mr. Gouvy is convinced that it can take the place of coal in many instances for the heating of open-hearth and other furnaces in which a regular temperature and a neutral atmosphere are required.

The advantages of tar oil, are identical with those of naphtha, with which latter fuel Mr. Gouvy worked in Russia, and can be stated as follows in comparison with coal:—(*a*) Reduction in tonnage transported owing to greater efficiency; with mazout the ratio is 1 to 1·6; (*b*) almost total absence of waste during transport and transhipment, when tank wagons or tank boats are available, also suitable pumps, piping and receivers; (*c*) maximum utilisation of the fuel, absence of clinkering and no stoppages, both of which latter disadvantages are unavoidable with coal, either when this is burned in a grate or utilised in producers; (*d*) easy and accurate regulation of temperature by the simple action of valves; (*e*) minimum oxidation of all metallic surfaces, subject to the heat, and purity of the flame, owing to the absence of sulphur; (*f*) higher and more regular temperatures than obtainable with coal; (*g*) greater simplicity of the furnaces using oil fuel, absence of chimney and flues, a draught being unnecessary, even detrimental to efficiency.

The question of recovery of the whole of the gas from the coke ovens is emphasised in the report from which we quote, as being one which will have to be taken into consideration by all coke-oven builders in every new installation. If 1 ton of coal used for coke making be taken as giving an average of 280 cub. metres (9,888 cub. ft.) of gas at about 4,500 calories (505 British thermal units per cub. ft.), it is found that the recovery coke ovens combined with regenerators for heating the air of combustion take up for distilling the coal 112 cub. metres (3,955 cub. ft.), equal to 40 per cent. of these rich gases, leaving 60 per cent., or 168 cub. metres (5,933 cub, ft.) available, which represent, approximately, 756,000 calories (about 3,000,000 British thermal units). But if ordinary producer gas is used for heating the coke ovens, and advantage is taken of double regenerators heating up both this gas and the air supply, then the whole of the 280 cub. metres of gas, representing, approximately, 1,260,000 calories (about 5,000,000 British thermal units) per ton of coal will be available. Therefore, a series of coke ovens treating 100,000 tons of coal annually would, under these conditions, yield about 5,800 h.p. in gas engines, instead of only 3,500 h.p. now available. In the case of coke ovens located close to the blast furnaces, the gas from the latter, yielding 900 calories to 950 calories per cub. metre (104 British thermal units per cub. ft.) can be utilised for working with the coke ovens; but the gas required can also be obtained from producers built for low-grade fuel—coke or slack coal, lignite, shale, peat—available in each particular case, the consumption of fine coke, for example, not exceeding 150 kilos. (330 lb.) per ton of coal distilled in the coke ovens. The figure is 115 kilos. (253 lb.) at the Vienna Gas Works.

Mr. Gouvy lays stress upon the following points:—(*a*) Approved types of producers, adapted to low-grade fuel, should be used exclusively, such, for example, as the Mond gas producer, which can take screenings and shale containing as much as 50 per cent. of ash, and yielding gas having 1,100 calories to 1,200 calories per cub. metre (129 British thermal units per cub. ft.); (*b*) the producer gas should be cleaned so as not to lead to the choking up of the coke-oven flues. In large installations, the recovery of by-products from the producers can also be taken into account, the distillation of lignite in a producer yielding from 10 per cent. to 15 per cent. of tar. There is no difficulty in the use of peat in the producers; (*c*) the time taken in the distillation of the coal has to be adjusted according to the quality of the coking-coal dealt with, and, contrarily to what obtains in gas-lighting plants, the quality and output of coke have always to be the first consideration, as is well-known.

The application of coke-oven gas to the manufacture of ammonium nitrate on the Haeusser process, experimented upon shortly before the war by Messrs. de Wendel, at Hamm (Westphalia), would enable, as it were, the storing up of the excess of gas not utilised for power or lighting during certain hours of the day, in the shape of a solid product, ammonium nitrate, or, in that of a liquid product, nitric acid.

Dealing with blast furnace gas, Mr. Gouvy, in his report, states that this is now utilised as a matter of course in all well-thought-out works. In this connection, he states that the blast-furnace gas should be submitted to a rough cleaning at least before its utilisation in the Cowper stoves for heating the blast, in order better to utilise the heating surface of the apparatus. At the same time, the ancient methods based upon the draught at the chimney, which is generally too active, and leads to an unsatisfactory utilisation of the heating surface, should be improved, and the air of combustion should be delivered to the apparatus at a pressure equal to that of the gas coming from the gas purifier; this would facilitate the mixture of air and gas, and would render possible the heating of the air in an economiser placed between the Cowper stoves and the chimney. Blast furnace gas can also be used in gas engines and steam produced from the heat of the exhaust from the latter. It can be utilised, further, to heat the coke ovens, as stated above, with or without a complement of producer gas, so as to render available for other purposes the total quantity of rich gas proceeding from the coke ovens.

As an interesting example of the practical possibility of utilising blast-furnace gas, the report gives the following figures, showing the distribution of 120,000 cub. metres (about 4,237,000 cub. ft.) of gas per hour, produced in five furnaces which take together 635 tons of coke per twenty-four hours, at the Georg-Marienhütte, Westphalia:—

	Volume of Gas per 24 Hours.		Distribution.
	c.m.	cub. ft.	per cent.
Cowper stoves (gas roughly cleaned)	48,000	(1,695,200)	40·00
Gas engines for electrical purposes, total power 5,600 h.p. (gas fully cleaned)	16,800	(593,300)	14·00
150-ton and 250-ton mixers	18,960	(667,500)	15·80
Cast Iron foundry (for drying moulds and heating the drying stoves)	1,056	(37,200)	0·88
Two heating furnaces (for rolling mills)	3,372	(119,100)	2·81
Pits serving the blooming mill	2,316	(82,000)	1·93
Boilers for steam make-up for the blowing engines (steam raised by waste heat from coke ovens)	11,796	(417.000)	9·83
Losses in flues and at furnace top	5,904	(208,400)	4·92
Excess as a reserve	11,796	(417,000)	9·83
Total	120,000	(4,236,700)	100·00

The dust in the blast-furnace gas is generally from 4 gr. to 16 gr. per cub. metre (0·6 lb. per 1,000 cub. ft.); in certain cases, it reaches 25 gr. (1·5 lb. per 1,000 cub. ft.). The percentage of iron in the dust may justify agglomeration by briquetting or by sintering, briquetting being more especially applicable to dust containing from 25 per cent. to 40 per cent. of iron and of irregular composition. Sintering is suitable for less rich dust and dust which varies in quality; this latter can be mixed with small ore. Some dust, especially that which proceeds from the dry-cleaning process, has great agglomerating properties and can be used for briquetting under a press, the briquettes being afterwards hardened in an autoclave or in the open.

The report also reviews the various uses to which blast-furnace slag can be put, and refers briefly to other by-products from the manufacture of pig-iron.

In the chapter on steel works, Mr. Gouvy mentions the recuperation of the waste heat from open-hearth furnaces, and refers to the work carried out by the Hoerde Company, Ruhrort; this company fitted to a 50-ton furnace, making four casts per twenty-four hours, and burning 250 per cent. of coal in the gas generators, a Garbe steam boiler, having a heating surface of 500 sq. metres (5,382 sq. ft.), with direct artificial draught by a fan. An economiser of 175 sq. metres (1,883 sq. ft.), formed part of the installation and reduced the tem-

perature of the gases from 450 deg. to 190 deg. at the entrance in the fan. The boiler supplied 4,000 kilos. (8,800 lb.) of steam at 8 kilos. (113 lb. per square inch) per hour, or 96,000 kilos. (211,000 lb.) of steam for 200 tons of steel, equal to 480 kilos. (1,057 lb.) of steam per ton of steel, and 1·92 kilos. per kilo. (1·92 lb. per lb.) of coal in the gas generators. Reckoning the value of a ton of steam at 2.50 francs (2*s.*), for 5,000 hours, the recuperation in the shape of steam amounts to 50,000 francs (2,000*l.*) in the year.

Under this head, Mr. Gouvy concludes by stating that if in the open-hearth furnaces, the principle were adopted of blowing in air at an equal pressure to that of the gas, as advocated by him in the case of Cowper stoves, there can be no doubt that this method, combined with artificial draught direct or induced, would not only allow the production of steam referred to, but would lead also to regulating the working of the open-hearth furnaces at will and independently of the chimneys and atmospheric conditions.

FUEL ECONOMY IN THE UNITED STATES.

By D. BROWNLIE, B.Sc.Hons. (Lond.), F.C.S.

AT the spring meeting of the American Society of Mechanical Engineers, held at Worcester, Mass., June 4 to June 7, 1918, much attention was given to the question of fuel economy. Prior to the meeting, the society had sent out the following list of questions to representative engineers throughout the United States :—

1. What are the economic effects of impurities in coal ?
2. To what extent is fuel oil likely to be used as a substitute for coal ?
3. How can soft coal be burned without smoke in marine boilers ?
4. What are the possibilities in the direction of the utilisation of anthracite wastes ?
5. What instruments are useful and desirable in the boiler room as aids in saving coal ?
6. What is essential to the economical operation of hand-fired boiler furnaces when using soft coal ?
7. To what kinds of plants and coals are the different types of mechanical stokers respectively adapted, and what is the limiting factor to their use in the small plant ?
8. What experience have you had in the use of wood as a fuel ? To what extent is wood available as a fuel ?
9. What coal economies can be effected in residence heating ?
10. What coal economies can be effected in the small steam plants ?
11. What experience have you had with the storage of coal ?
12. (*a*) To what extent and where will the gas producer be used to produce economies ?
(*b*) To what extent is natural gas being used as a fuel for power purposes ?
(*c*) What is the relative economy of the locomotive of 1900 to-day ?
(*d*) What proportion of the coke is made in by-product ovens ?
(*e*) What are new and important developments in methods of burning coal ?
(*f*) What economies have resulted from recent practise n making brick settings leakless ?
(*g*) Is automatic air supply correctly proportioned to coal supply ?
(*h*) Miscellaneous—school heating—insulation—smoke prevention.

Over 60 engineers responded with contributions* and the society have published in the form of a symposium,* concise selections from the contributions received, the whole report containing such a mass of useful information and opinions on the vital question of fuel economy, that it merits a most careful consideration, especially by all interested in the economical generation of steam.

The field covered is so vast that it would take many articles to deal with it adequately, but it seems to the author that two points in the report are of special interest, namely, the attitude taken up by the American Government with regard to the whole question of coal economy, and question No. 5, "What instruments are useful and desirable in the boiler room as aids in saving coal ?"

We learn that the United States is now facing a shortage of 80,000,000 tons of coal per annum, and that 35,000 miners have already been taken into the army, so that the question of fuel economy is quite as serious in America as it is here. The American Government evidently realise the gravity of the situation, and are taking the most drastic steps to deal with the problem. A fuel engineering division has been formed in the United States Fuel Administration in Washington under the Bureau of Conservation, and comprises two departments, railroads and industries, the latter covering all power plants not belonging to railroads. The industrial section devotes itself exclusively to the work of the conservation of fuel in stationary boiler plants, and to the efficient use of steam after its generation. The organisation comprises the central Office at Washington, with an administrative engineer appointed (or to be appointed) in each coal-using state, attached to the Federal Fuel Administration of that state. This administrative engineer has a consulting board of competent engineers, and a staff of technical and clerical assistants and inspectors. The fundamentals of this national programme are as follows :—

(*a*) Personal inspection of every power plant.
(*b*) Rating and classification of every power plant in the country, in classes, depending upon the thoroughness with which the owner conforms to the recommendations of the United States Fuel Administration.
(*c*) At the discretion of the Federal Fuel Administration, the supply of coal to any needlessly wasteful plant may be curtailed or stopped.

This plan is now in operation in Pennsylvania, the largest coal-consuming State, and in Connecticut, and other States are rapidly being taken in hand. The standard recommendations of the United States Fuel Administrations for the conservation of coal in stationary boiler plants are substantially as follows :—

1. *Fuel.*—That means may be provided for measuring and recording the amount of fuel used each day or shift.
2. *Feed-water.*—That boiler-feed water be heated by exhaust steam or waste heat, and measured.
3. *Air supply.*—That a correct amount of air be supplied to the fuel and proper means be provided for measuring and regulating the draught.
4. *Clean heating surfaces.*—That boiler heating surfaces be kept clean inside and out.
5. *Boiler and furnace setting.*—That the furnace and setting be kept in good repair and free from air leakage.
6. *Insulation.*—That exposed steam furnaces wasting heat by radiation be covered with suitable insulating material.
7. *Engine-room and heating system.*—That wherever possible, exhaust steam be utilised to the exclusion of direct steam from the boilers.
8. *Supervision.*—(*a*) That a competent employee or committee be detailed to supervise the work of fuel conservation in boilers and engine plants.
(*b*) That a competent committee be appointed in charge of the work of fuel conservation in the buildings and shops outside of the power plants.

To assist in the above work, we learn also that the United States Fuel Administration have prepared a 50-minute film of moving pictures, showing good and bad operation in the steam boiler plant methods of testing boilers, &c., and these pictures will be available in each State. It would be very interesting to know the present working efficiency of boiler plants in America, so as to be able to determine what actual saving will result from the above comprehensive plan. No figures are given (presumably because they are not known), but it is tolerably certain that at any rate, the efficiency will not be higher than in Great Britain. The author has given in this journal (July 12 and July 19, 1918), "Coal Saving by the Scientific Control of Steam Boiler Plants") the results of eight years' continuous work in investigating the present working efficiency of steam boiler plants in Great Britain, and has shown that for 250 typical plants, the average net working efficiency is only 60·09 per cent., divided as follows :—

	No. of plants.	Percentage.
1. Over 80 per cent. efficiency...	2	0·8
2. 75 per cent. to 80 per cent. ...	9	3·6
3. 70 per cent. to 75 per cent. ...	13	5·2
4. 65 per cent. to 70 per cent. ...	30	12·0
5. 60 per cent. to 65 per cent. ...	44	17·6
6. 55 per cent. to 60 per cent. ...	62	24·8
7. 50 per cent. to 55 per cent. ...	47	18·8
8. Less than 50 per cent. ...	43	17·2

The American report mentions that in the anthracite mines of Pennsylvania, where about 80,000,000 tons of coal are mined per annum, that 1 ton of anthracite is consumed at the mines for every 8 tons to 9 tons mined, or over 10 per cent. of the coal raised. This would appear to be even worse than the figures of about 7·0 per cent. for Great Britain in all classes of mines. The author has given in the article already mentioned, the results of 70 typical colliery steam boiler plants in Great Britain, showing an average net working efficiency of only 51·2 per cent., as compared with 60·09 per cent. for all the industries of the country.

The author has also pointed out that by adopting modern scientific methods of steam generation, it is possible to run a boiler plant under average conditions on 75 per cent. efficiency, corresponding in Great Britain to an average saving of no less than 20 per cent. in all industries, and in the case of collieries only to nearly 30 per cent.

The above scheme of the American Government, if efficiently carried out, should result, therefore, in an enormous saving of coal in the United States. The standard recommendations at first sight may appear very elementary, but recommendations 1 and 2 above would in Great Britain cause something of a revolution in boiler practice. In the 250 plants already examined by the author, only 25 plants were fitted out with apparatus to determine regularly the water evaporated, and in several of these cases, the meter in use was inaccurate, and probably not 5 per cent. of the boiler plants of Great Britain are fitted with accurate water-measuring apparatus in regular use. The report also gives no indication of the figures in this respect for American boiler plants, but, as before stated, the general conditions are probably no better than in Great Britain.

The United States Government also appears to be taking drastic action with regard to the amount of ash in coal. The rapid development of war industries has caused a greatly increased demand for fuel, competition has been reduced because of this, and as a consequence, the amount of impurities in anthracite and bituminous coals had greatly increased during the winter months of 1917. An appeal was made to prevent this increase of ash, but met with little or no response, and the United States Fuel Administration took strong action, particularly in the anthracite region of Pennsylvania. They formulated rulings limiting the percentage of slate, bone and small coal to be permitted by the Government in all sizes of anthracite, and inspectors were appointed to condemn all coal below standard. A list is given of the various qualities of anthracite and the amount of impurities allowable. Thus, all steam anthracite coal containing more than 20 per cent. ash is condemned. The scheme has been so effective that for the month of May last less than ½ per cent. was condemned by the inspectors of the daily production of 250,000 tons of anthracite in Pennsylvania, and there has resulted a sensational increase in the quality of the coal delivered.

For example, during the months of January and February more than 50 per cent. of the coal marketed contained excessive amounts of impurities and would have been condemned under the above scheme.

An appeal is also being made to economise in oil fuel in every direction, and to save transportation of oil, steam users on the Atlantic Coast are urged to use coal instead of oil as a fuel.

With regard to the questions, "What instruments are useful and desirable in the boiler-room as aids in saving coal ; what class of equipment has been of the most value to you, and how ?" the author will endeavour to offer replies from the point of view of his own experience. The only method of running a boiler plant economically is to regard it as a little factory in itself, whose raw products are essentially fuel, water and labour, and whose finished product is steam at a given required pressure.

The instruments useful and desirable in the boiler-house are those which enable us to record the complete performance of the boiler plant, that is to say, to measure the amount of fuel and water used (consumption), and the amount of steam produced (production), together with those instruments which can be considered to be auxiliary, that is to assist in controlling the working of the plant, so as to obtain the highest efficiency. In most boiler-plants in Great Britain to-day, practically the only instrument in general use is the boiler-house pressure gauge.

The first essential is instruments for measuring the amount and quality of fuel and water. A continuous weekly record must be kept of the per-

* "The Economical Use of Fuel. A symposium contributed to the Worcester Meeting of the American Society of Mechanical Engineers," held on June 4th to 7th, 1918.

formance of the plant, and a complete boiler-house log entered up each week. If this is not done, the plant is being worked in the dark, and it is impossible to get the most economical results.

The method of weighing the fuel presents little real difficulty on any boiler plant. It is comparatively simple to take an exact record of the exact weights of fuel delivered daily into the firehole, and at the end of the week to level up the bunkers so as to get the net amount burned per week, and for ordinary-sized plants no separate weighing machine is necessary.

For very large plants the automatic coal weighing machine is a most valuable instrument, and separate smaller machines can be installed on each smaller block of boilers or separate large tubular boilers.

The measurement of the feed-water presents greater difficulties, but these difficulties can be surmounted. The continuous and accurate weekly recording of the weight of water, containing more or less grit, suspended matter and scale-forming elements at varying temperatures from 60 deg. F. to 200 deg. F., delivered into boilers is in practice a difficult operation, and the author has had many years' experience of these difficulties.

Some form of water-measuring apparatus is, however, an essential part of any boiler plant, and undoubtedly the most important of all the instruments in the boiler-room. There is about a dozen or so of boiler-feed water-meters on the market divided into two general classes, pressure-type meters and non-pressure type. The pressure type measures the water under pressure, and is generally placed between the boiler-feed pump and the economisers, and sometimes between the economiser and the boilers. A satisfactory arrangement is also between the water supply and a large reserve tank from which the boiler-feed pump takes its supply of water, the level in the tank being kept constant by a float.

The open type measures the water flowing into the reserve tank, either on the "V" notch or "weir" principle, or weighs continuously successive small tanks of water, and delivers them into the store tank. The author has had experience with more or less all makes of meters, but cannot for obvious trade reasons give the advantages and disadvantages of each. One very important point to remember is, however, that no meter is perfect, because of the difficulties mentioned, and it is very necessary to fix up the meter on the right lines to get satisfactory results. In the first place, any meter must have a complete bye-pass arrangement, so that it can in an emergency be quickly cut out of the feed-water circuit without interfering with the running of the plant. This may appear an obvious precaution, but in practice it is very rare indeed that a proper bye-pass circuit is installed.

Secondly, it is absolutely essential to arrange the meter so that it can be tested for accuracy quickly and without trouble. It is no use using an instrument of precision and having no method of checking its accuracy, particularly bearing in mind the liability to error of all types of water meter.

With the pressure type of meter, the most convenient arrangement is that of a special bye-pass arrangement on the circuit connected to a small calibrated tank of, say, 500 gals. or 1,000 gals. capacity, which has been calibrated by actual weighing, and can be corrected for temperature by means of a curve.

By a suitable arrangement of valves it is then an easy matter to run 500 gals. or 1,000 gals. through the meter and into the testing tank, and thus check the accuracy. The whole test can be done in, say, 20 minutes, without interfering with the accuracy of the week's records. The author also recommends for pressure-type meters a back-pressure valve to equalise the action for the boiler-feed pump, a safety valve, and an arrangement whereby the temperature and a sample of the feed water can be taken as actually going through the meter into the boilers. This is especially necessary when varying sources of feed-water are used, and mixed. For open type meters the reserve tank itself can be used as a testing tank by accurately calibrating the amount of water in, say, a given 2-ft. depth, and stopping the feed-pump and allowing the above amount of water to run through the meter.

As regards instruments for the analysis of coal what is required for this is some form of calorimeter for determining the heat value, a muffle furnace for the ash, and the usual laboratory apparatus for estimating the moisture. The exact type of calorimeter necessary is, of course, largely a matter of opinion, but the author strongly recommends the "oxygen bomb" type, in which the heating value of the damp coal as used is directly determined by ignition in a closed bomb under high-pressure oxygen. This type of instrument is expensive, but is well worth the expense both for accuracy and quickness of working.

The next most important instrument in the boiler-house is undoubtedly the combustion recorder, which, if rightly used, is an invaluable instrument. In the first place, a reliable instrument must be selected.

There are nine or ten makes at present on the market, and the author is of the opinion, after prolonged experience with most of them, that two or three are much superior to the others. It is, as before, not possible to give the advantages and disadvantages of each type. Secondly, the instrument must be erected on right lines in the firehole where the firemen can have it under easy observation. It is no use whatever erecting the instrument in the engine-house or other similar spot or even in an inaccessible position, such as on the top of the boilers. It is difficult enough to get firemen to take an interest in working with a combustion recorder when it is close at hand, and the fact of having to climb a ladder or walk a few yards is sufficient to cause the instrument to be neglected at once. Yet, these elementary facts are not generally understood, and very few CO_2 recorders are erected on sensible lines. Just recently the author came across a large and modern plant of 32 "Lancashire" boilers, the economisers being at the back of the boilers in separate blocks of 384 tubes for each four boilers. The plant was fitted with four CO_2 recorders, one for each eight boilers, and these were fitted right down on the far side of the economisers from the boilers between the bottom boxes of the economiser and the back wall of the boiler-house. In order to get at them from the firehole, it was necessary to climb up the front of the boilers, walk over the top of the boilers under a vast steam-pipe range (with superheated steam) only about 3 ft. above the top of the boilers, walk along the hot main flue and descend a vertical iron ladder into a narrow well, very hot, and very dark. The engineer who designed this plant has obviously not the slightest idea of the practical use of the CO_2 recorder.

It is very useful to have an "Orsat" apparatus for carrying out analyses of flue gases by hand as a check on the combustion recorder and to determine the amount of CO present in the gases.

Of almost equal importance are temperature-indicating instruments, thermometers or pyrometers. It is very necessary to know the flue gas temperature, before and after the economisers, as a check on the performance of the economiser in reducing the heat of the exit gases, but more important still in detecting leakages in the brickwork. When a boiler plant has once been got right in the brickwork, the temperatures remain remarkably uniform, say, 650 deg. F., before the economiser and 300 deg. F. after.

A slight leak in the brickwork causes a perceptible drop in the temperatures and forms a most sensitive indication.

The pyrometers in use should be of the thermo-couple type permanently installed and connected up to a clock dial in the firehole, so that by means of a switch any temperature can be taken at once. The instrument should be connected up in the flue gas and in the feed-water before and after each set of economisers, and in each superheater, and a log kept of each of these temperatures, say, every half-hour. Unfortunately, it does not seem to be practicable to be able to determine continuously the temperature of the fires themselves.

Of almost equal importance are draught-gauges to indicate the draught. The author recommends an ordinary type of "U" tube fitted with a sliding ruler between the limbs of the "U" tube to observe the draught in inches water gauge, the whole enclosed in a small wooden case with glass door to keep out the dust. Such an apparatus can be made for a few shillings and is invaluable. The author recommends that such a draught gauge be fitted on the brickwork front of each boiler, connected by a ¼-in. W.I. pipe to the side flues, or exit of the main flue. The draught at the chimney base (or fan inlet, if induced draught is in use) should be taken with a recording draught gauge installed in the firehole, so that a permanent curve is taken continuously.

A recording gauge is at all times a very valuable instrument.

All instrument work should be focussed in the firehole itself and the difficulty of dust and dirt got over by constructing extra dirt-tight cases.

The American engineers generally, in answering this question, point out very correctly that the idea of instruments and recorders is not to "show up" the fireman, but to assist him, and they all emphasise the necessity of a complete equipment of instruments. They divide these instruments into two classes, those for recording the results and those for showing the conditions.

The instruments for recording the results are:—

1. Quantity: Recording coal scales.
   Recording steam or water meters.
2. Quality: Coal calorimeter and moisture scales.
   Feed water thermometer.
   Steam pressure gauge and thermometer.

The second group of instruments is intended to direct the processes by controlling conditions.

Individual flow indicators.
Individual draught gauges.
Individual flue-gas thermometers.
Flue-gas analyser.

They point out very clearly that any investment in instruments is a waste of money, and will lead to demoralisation unless means are provided for

(*a*) Training men to use them.
(*b*) Stimulating men in the proper use of them.
(*c*) Complete exact and continuous recording.

One case is given of a most elaborate and complete equipment of instruments, costing about 2,000 dols., on an averaged-sized plant burning, say, 150 tons to 250 tons of coal a week. As a result of this equipment, the saving per annum was 8,620 dols. for an exact expenditure of 2,080.46 dols., an investment yielding 400 per cent. dividend. It is not stated whether this is the real net saving after deducting the extra labour required in looking after the equipment, but even if this is not taken into account, it is obvious that the real net saving is enormous.

The American engineers lay great stress on the necessity of steam meters to record the amount of steam given out by each boiler, and to determine the amount of steam used by different processes and departments. It is obvious that if a reliable and accurate steam meter could be obtained, it would be undoubtedly the most useful and valuable of all instruments in the boiler-house. The author has had considerable experience with one or two types of steam meters, and has had reluctantly to give up the idea of steam meters. If there are types of steam meter in use in America which will give accurate results, then they should be imported into this country without delay. It seems fairly easy to measure steam in a long straight pipe with a uniform flow of dry steam and an even pressure, but the difficulties commence when there is a large number of bends in the steam-pipe circuit, when the demand for steam fluctuates violently, when condensation takes place, and when the pressure varies.

They also lay stress on the necessity of combustion recorders together with an "Orsat" apparatus. They say any boiler plant of 1,000 h.p. and over is justified in installing a CO_2 recorder.

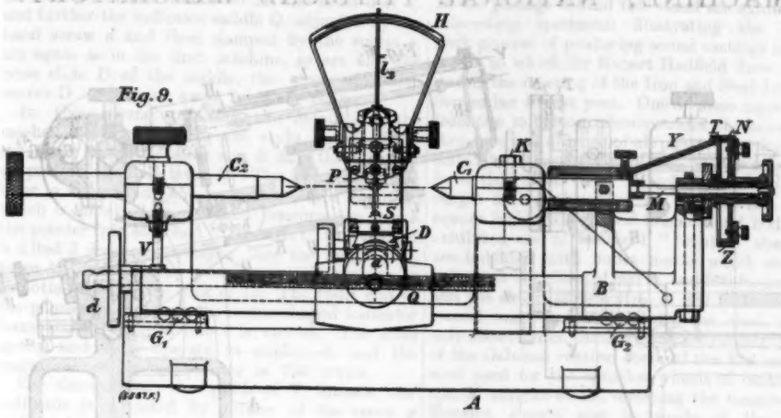
The general impression from the perusal of the American answers to this and the other questions is a general elasticity of mind, of a freedom from conservatism and a restlessness to be up-to-date that is distinctly refreshing in comparison with most English ideas on the subject.

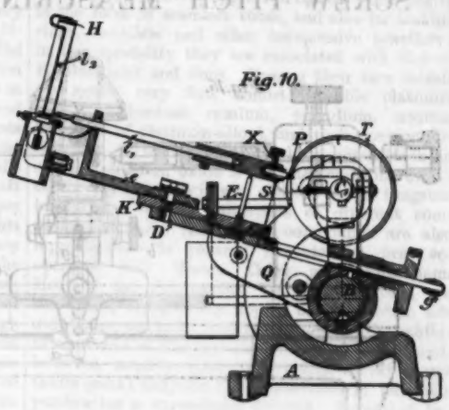
THE NATIONAL PHYSICAL LABORATORY IN 1917-18.

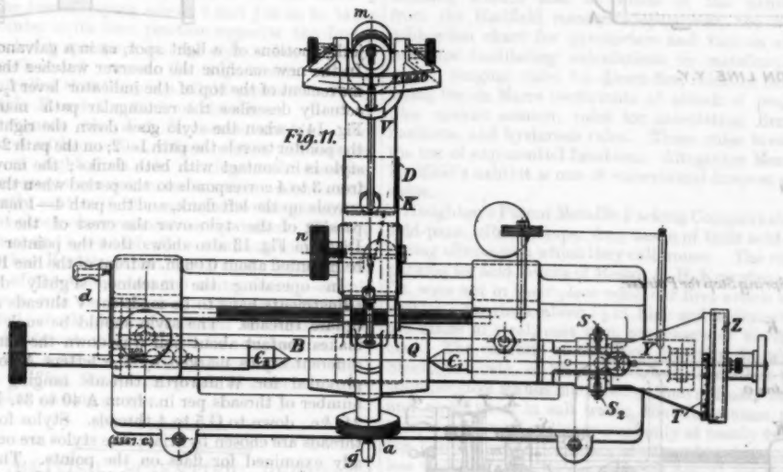
(*Continued from page* 180.)

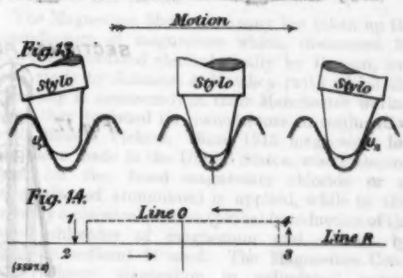
Screw-Pitch Measuring Machines.—The two screw-pitch measuring machines which we illustrate this week on pages 209 and 210, namely, one for screws

SCREW PITCH MEASURING MACHINE; NATIONAL PHYSICAL LABORATORY.









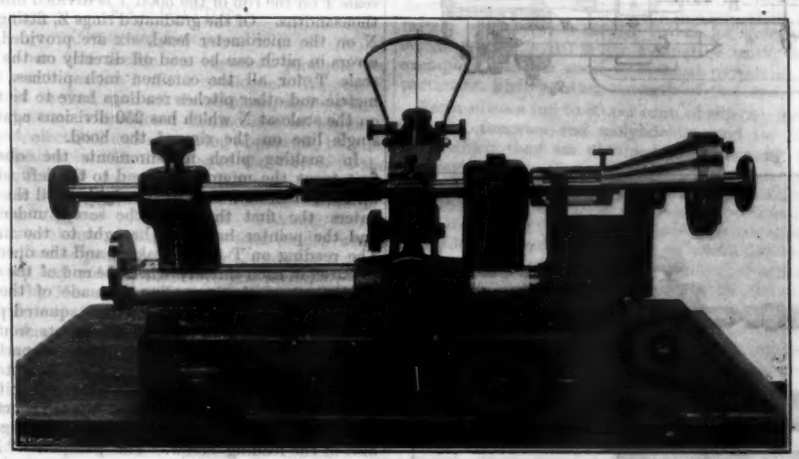


FIG. 12.

up to 3 in. diameter and up to 8 in. overall length, and the other for screws of 6 in. diameter and 9 in. maximum length, have the distinctive features of the machine we described last year.

The machine dealing with screws of 3 in. diameter and up to 8 in. in length is shown by the outline drawings Figs. 9 to 11, the photograph Fig. 12, and the smaller diagrams Figs. 13 and 14. It consists of the bed A, the sliding bar B, carrying the micrometer and the indicator, and the saddle Q. The screw under test is mounted between the centres C_1 and C_2. C_1 should not be moved after once being adjusted, the long centre C_2 can be shifted. The sliding bar B runs on two groups of three balls, G_1 and G_2; the upright portion of the bar is forked so as to clear the centre C_1, and is guided by two set screws S_1 and S_2 which prevent undue shaking of the parts.

The micrometer head M is fixed at the extreme end of B and bears with its rounded point against a flat-ended anvil on the tail end of the centre C_1; a weight keeps the parts in contact. The micrometer head M is provided with the dial N over which graduated rings Z are fitted, bearing against the scale T of the conical head Y, which is attached to the tail of C_1.

The indicator saddle Q is adjustably carried on B and fixed in position on it by the aid of the long screw *d* and then clamped by the screw *a* (Fig. 9). The indicator itself is fixed to the cross slide D of Q, which is moved towards or away from the centres by turning the screw *g* (Fig. 10). The movement introducing the stylo point or feeler P (of hardened steel) into one of the grooves of the screw under test is produced by turning the micrometer, as we shall see. The stylo P is fixed to the one end of the lever l_1 which is supported above the cross slide by a very thin steel trip S and the strut E—characteristic features of Mr. Eden's devices; the other end of the lever l_1 is forked and embraces a second lever l_2 at a point a short distance above its pivots.

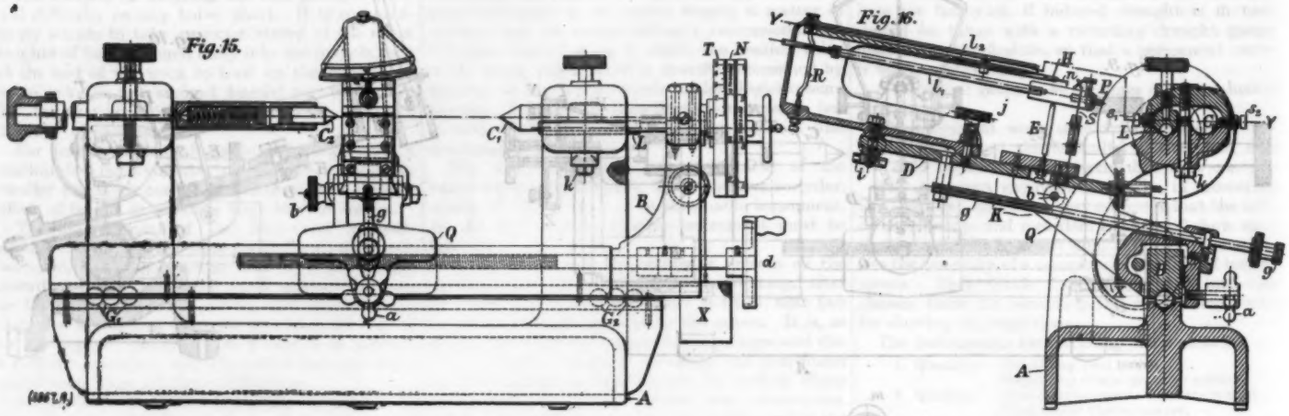
The pivots of l_2 are mounted in a cylinder (on top of Fig. 11) which is itself pivoted on a line parallel to the machine centres; *m* is loaded so as to keep l_2 in contact with the fork of the first lever. The upper bent pointer end of l_2 moves over the brass lyre-shaped strap H (seen at the top of the photograph, Fig. 12) on which a horizontal line R and a vertical line O are marked (Fig. 14).

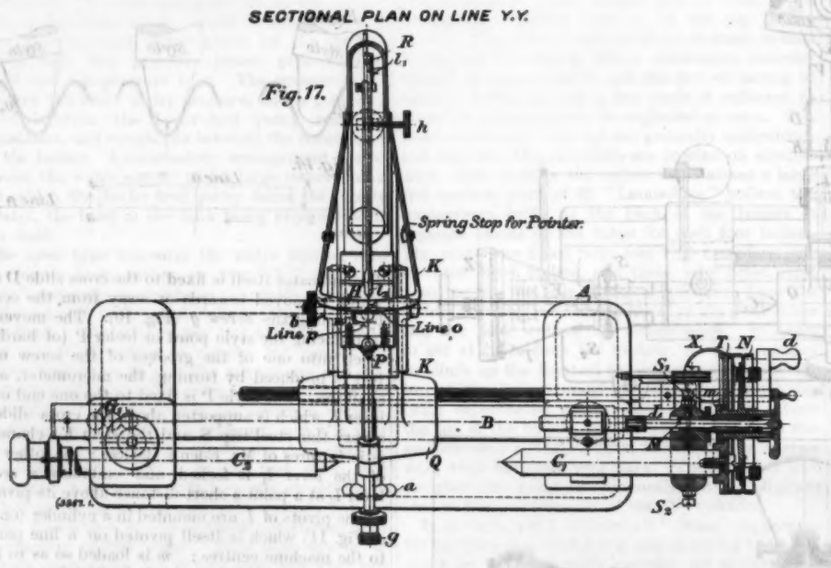
The steel-strip S already referred to acts both as a pivot for the lever l_1 and gives it a little lateral play. In the central symmetrical position of the stylo, S is straight; when the stylo is moved backward, S merely bends; but when the stylo is shifted to the right or left, it twists about the axis X which thus becomes the vertical fulcrum of the lever l_1. The pointer magnifies this movement about 300 times.

These features will be better understood from the diagrams, Figs. 13 and 14. The arrow marks the direction of the movement of the bar B. At U_1 the stylo touches the left flank of a thread, and l_2 is deflected to the left; at U_2 contact and deflection are to the right; in the intermediate symmetrical position the stylo touches both flanks, the pressure on the flank having changed from left to right and the pointer moving over the arc H. In this symmetrical position the pointer is opposite O (Fig. 14) and the pressures on both flanks are equal, and a reading is taken at this moment. As the micrometer movement is continued, the point P climbs up the thread, moves over the crest, and then bears against the left flank of the next thread, until it is fixed symmetrically there; then a new reading is taken.

In the machine which we described last year the movements mentioned could be watched by the

SCREW PITCH MEASURING MACHINE; NATIONAL PHYSICAL LABORATORY.





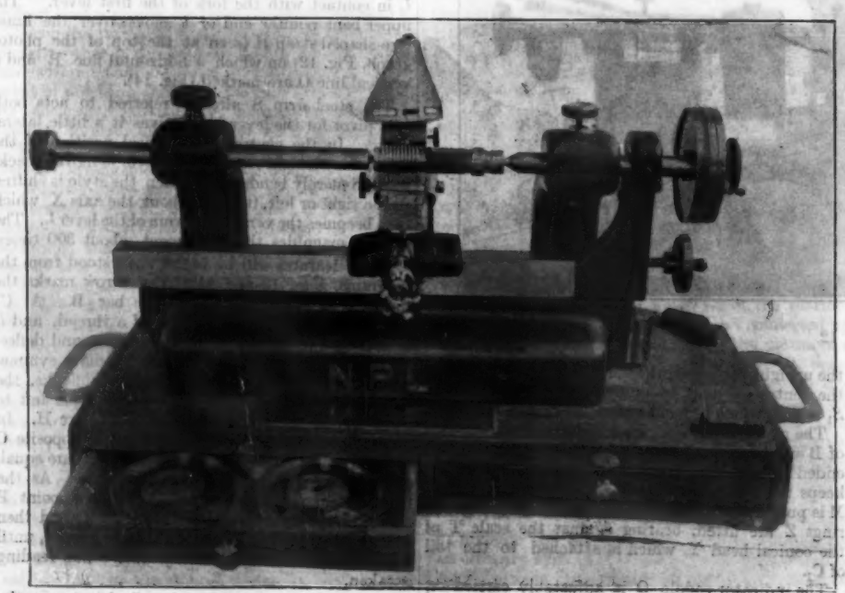


Fig. 18.

jerky motions of a light spot, as in a galvanometer. In the new machine the observer watches the jerky movement of the top of the indicator lever l_2. This actually describes the rectangular path marked in Fig. 14; when the stylo goes down the right flank, the pointer travels the path 1—2; on the path 2—3 the stylo is in contact with both flanks; the movement from 3 to 4 corresponds to the period when the stylo travels up the left flank, and the path 4—1 marks the passing of the stylo over the crest of the thread Diagram Fig. 13 also shows that the pointer should be mounted about 0.06 in. in front of the line R.

In operating the machine, slightly differing adjustments have to be made for V threads and for square threads. The stylo should be such that it makes contact about half way down the flank, and different stylos marked by the letters A to G are provided for Whitworth threads ranging in the number of threads per in., from A 40 to 34, B 32 to 24, &c., down to G 5 to 4 threads. Stylos for other threads are chosen by trial; the stylos are occasionally examined for flats on the points. The fixed scale T on the rim of the hood Y is divided into ten-thousandths. Of the graduated rings Z, fitting over N on the micrometer head, six are provided, and errors in pitch can be read off directly on the fixed scale T for all the common inch pitches. For metric and other pitches readings have to be taken on the scale at N which has 250 divisions against a single line on the rim of the hood.

In making pitch measurements the observer first turns the micrometer head to the left to take up back-lash, and then to the right, until the stylo enters the first thread of the screw under test and the pointer has been brought to the line 0. The reading on T is now taken, and the operation repeated in each thread; when the end of the screw is reached, a check reading is made of the first thread. The results are plotted on squared paper. If the screw were perfect, all the points would be on a horizontal line at equal distances apart. In reality a somewhat irregular curve will be obtained, which will rise (slope upward) when the pitch is relatively too long, and fall, when it is too short, and which will show the other defects of the gauge and also of the leading screw. The pamphlet "Notes on Screw Gauges," to which we have already referred, exemplify how the pitch errors, if not capable of being read off directly, can be found by subtracting the theoretical from the actual readings.

The second machine, which we illustrate this week, is for taking measurements on screws, up to 6 in. in diameter and 9 in. long. It is illustrated in Figs. 15 to 18, annexed, and has the same chief parts as the first, the bed A with centres C_1 and C_2, the latter fitted with a spiral spring preventing it from turning during the measurement, and the sliding bar B with its V groove moving on the balls G_1 and G_2 in the corresponding groove of the bed. The upright portion of B allows the centre C_1 to pass through a hole (not a fork, as in the first machine); the set screws S_1 and S_2 are as explained.

The micrometer head M differs in construction from that of the smaller machine, and it is pressed against the flat-ended anvil L by the weight X; the graduated dial N on M, the fixed dial T, and further the indicator saddle Q, adjusted by the hand screw *d* and then clamped by the screw *a*, are again as in the first machine, as are also the cross slide D of the saddle, the screw of which moves D towards or away from the centre.

In this second machine the details of the mechanism for actuating the stylo P are different, apart from the steel slip S and the strut E, supporting the first lever l_1. The free end of this lever is forked, and the fork embraces a crank R, which is pivotted on jewelled bearings, to which the pointer l_2 is attached. The axis of this pointer is tilted 3 degrees sideways; thus the weight of l_2 keeps the crank gently pressing against the one or the other side of the fork of l_1. The front end of the pointer moves over the sector-shaped indicator frame H, on which a line 0 is etched. The steel spring and strut operate as explained, and the magnification of the pointer is 750 times.

For determining the pitch of V threads the indicator is adjusted by means of the screw *g* and the two clamping screws *i* and *j* so as to bring the pointer in its free position opposite the line 0 without side pressure on the style. For pitching square-threaded screws the adjustment of *g* is so controlled that there is a slight pressure between the stylo P and the flank of the screw.

As regards the dial N, some machines are provided with one dial, others with a full complement of eight dials. In testing each machine, measurements are taken on a screw which is subsequently sent with the machine to the purchaser, so that check observations can be taken. The set-screws s_1 and s_2—which allow a full endwise motion of the bar B without too much shake between the points of the screws and the centre rod C_1—should not as a rule be disturbed; if they have to be adjusted, check observations will be necessary, as the adjustment might affect the calibration. By the aid of a special fitting for the indicator and a chuck holding the gauge, pitch measurements are also taken on ring gauges.

(*To be continued.*)

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

(*Continued from page* 178.)

In our first article on chemical products we kept within section 1 of the catalogue. We cannot attempt to deal with all the sections, and we shall not observe the sectional distinctions of physical, optical, electrical and measuring apparatus, because classification is difficult owing to the variety of the productions of many firms. When no address is given in our notice, the firm has a London address.

Chemical and Metallurgical Products.—The brilliant colours of the various lead oxides which are utilised as paints and cements, and in the accumulator and rubber industry, are strikingly displayed by Messrs. Cookson and Co., of Newcastle. Heated lead first turns into the grey sub-oxide Pb_2O, then into the yellow oxide PbO, known as massicot, or, when fused, as lytharge; both these products become darker coloured when hot, and their colour depends upon the subdivision. As ordinary by-products of furnace oxidation they were impure until special processes were worked out in Germany. In the new process as adopted by Messrs. Cookson, the intermediate product contains some finely-divided metallic lead which is subsequently removed. The orange lead, used together with dyestuffs in the manufacture of enamels, printing ink and paints, is another shade. Minium, or red lead, we should add, is Pb_3O_4, the chocolate-coloured peroxide of the accumulators is PbO_2. The products of the Hull and Liverpool Red Oxide Company, of St. Helens and Hull, are various shades, red, purple, chocolate, Venetian red, &c., of iron oxide for paints, ship's composition, anti-fouling materials, &c. The ultramarine and cobalt green and blue of Messrs. Reckitt and Sons, Hull, are cobalt pigments.

The metallurgy of iron is represented only by one firm, Messrs. Hadfield, of Sheffield, whose armour-piercing projectiles and "Hadura" hardened steel rolls (one pair of 8 in., one of 16 in.) strike the visitor's eye as he enters the exhibition. In the passage behind this stand are exhibited very interesting specimens illustrating the Hadfield-Jack process of producing sound castings in parallel ingots to which Sir Robert Hadfield drew attention during the meeting of the Iron and Steel Institute in September 19 last year. One of these ingots, halved from top to bottom, demonstrates the homogeneous structure and absence of all pipe; other ingots illustrate the manufacture of 9.2 in. explosive shells from this steel. The "Hecla" steel for aircraft ranges in tenacity from 50 tons to 100 tons per square inch. The tested helmets and body-shields exhibited are of Hadfield "resista" steel; they are indented with bullet marks which struck the helmet at velocities of 800 ft. and 900 ft. per second, and the shield at velocities of 600 ft. to 880 ft. per second and were stopped by the steel, although only about 1 mm. thick. There are further specimens of the Galahad rustless steel, of the Era manganese steel used for the sprocket wheels of tanks, and of special magnet steels, replacing the tungsten-steels. Mention should also be made of the exhibits from the Hadfield research department, the Main calibration chart for pyrometers and various slide rules for facilitating calculations in metallurgical work: ranging rules for direct fire, rules for calculating the de Marre coefficients of attack of projectiles against armour, rules for calculating Brinell hardness, and hysteresis rules. These rules involve the use of exponential functions. Altogether Messrs. Hadfield's exhibit is one of exceptional interest and value.

Haughton's Patent Metallic Packing Company show acid-pans, elbows, taps, &c., made of their acid-resisting silicon-iron which they call ironac. The ring-packing for acid towers of Messrs. C. H. Kempton and Co. were not in their place when our first article was written; the rings, about 1½ in. high and in diameter, are made in steel, cast iron, stoneware or vitrified clay. The exhibits of the Firth-Brearley Stainless Steel Syndicate, of Sheffield, demonstrate that the stainless steel stands much better than ordinary steel and nickel steel in salt water, that it assumes the temper colours of ordinary steel only at nearly twice the temperature of ordinary steel, and scales much less when kept at 700 degr. or 800 deg. C. for three days. The products exhibited, knives, strip for razors, springs, wire, sheets, valves for areoplane engines, roller bearings for submarine work, &c., exemplify also the good mechanical properties, in particular, high bending strength of the steel.

Ferro-silicons (up to 90 per cent. of silicon), ferro-chromes, tungsten and molybdenum and the ores from which they are obtained are shown by the Newcastle Alloy Company, tungsten and molybdenum in particular by Messrs. Duram, Limited, and the Edison Swan Company exhibits, together with the pointolite (tungsten rods or bead) lamps, molybdenum ores, metal and ore, also a new non-ferrous alloy tabasco which is recommended as both heat and acid-resisting for burner nozzles, the ends of glass-blowers irons, jets for glass enamel pots, combustion tubes and acid-bath baskets. Thermit products and the ores from which they are produced are exhibited by Blackwell's Metallurgical Works; the British Thermit Company, of Liverpool; Messrs. Thermit (Nobel's Explosive Company, of Glasgow, owners of the alumino-thermit patents); and the firm of Thermo-Electric, Limited, which founded by Mr. A. F. Maclaren, specialises in tungsten, molybdenum, chromium, ferro-chrome, ferro-vanadium and ferro-zirconium (a refractory). The alloys and compounds named are produced in electric furnaces from the ores of the mines of the company. The Mond Nickel Company shows as a novelty copper sulphate from Sudbury ores, also as a colloidal mixture for spraying potatoes. The very interesting exhibit of Messrs. Henry Wiggin and Co., of Birmingham, consists of nickel laboratory ware, crucibles, dishes, &c., and sheets of alloys; copper-steel (resembling copper), copper-nickel steel and cupro-nickel-copper (both like steel), copper-brass (like brass).

Messrs. Johnson, Matthey and Co., London and Manchester, have a very attractive exhibit of their various products, famous for their high purity. The liquid gold and silver for ceramic work used to be almost exclusively German products, as were also the rolled gold and silver applied in optical work, partly in the form of seamless tubes, and also for making rings, bracelets and other inexpensive jewellery; in this speciality they are associated with Messrs. R. Buckland and Sons. Among their rare metals we notice very fine, almost invisible platinum wire; ruthenium, osmium, palladium, iridium (contacts of platinum-alloy), and their compounds. Selenium is shown in small bars, pitch-black in colour; selenium oxide is a white crystaline mass; the brown tungsten bronze and the purple tungsten bronze are sodium tungstates of different compositions. Some rare earths compounds are also represented. As regards zirconia the firm co-operates with Messrs. Coley and Wilbraham. Most of the rare earths, we might remark, are colourless, though they appear coloured when not quite pure, as shown on several stands in the exhibition. Some of the rare earths seem to be coloured, however, notably ceria (canary-yellow), erbia and thulia (pink), didymia (chocolate-colour); but their purification is exceedingly difficult. Several of the earths occur in different oxides, and the colour problem is not solved.

The Magnesium Metal Company has taken up the manufacture of magnesium which, discovered by Davy and isolated electrolytically by Bunsen, was first made by Johnson & Matthey (with whom the company is connected) in their Manchester works; later they resumed its manufacture in conjunction with Messrs. Vickers. Since 1915 magnesium has also been made in the United States, where electrolysis (of the fused magnesium chloride or of magnesia and aluminium) is applied, while in this country a chemical process (probably reduction of the fused chlorides of magnesium and alkalis by metallic sodium) is used. The Magnesium Company shows magnesium in cylindrical ingots, more than 6 in. in diameter, in bars, wire, ribbon and powder; the colour of the metal is more silvery-white than that of aluminium. The metal is ductile and malleable, melts only at very high temperature, though it burns when heated in the air, and is exceedingly reactive.

The tinfoil of Venesta, Limited, is the foil, plain, lacquered, embossed and coloured, supplied in sheets or reels of pure tin (free from lead) for wrapping up cigars, sweets, &c.; the firm also exhibits collapsible tubes of tin or tin-coated lead for paster colours, rubber solution, &c. Messrs. Dyson & Co., of Ponders End, show their die castings supplied in alloys of aluminium, zinc, tin, lead, up to 4 lb. weight, by means of which parts of machines and instruments can be manufactured with a high degree of finish. The zinc and cadmium of Messrs. Chance and Hunt, of Oldbury, Birmingham, are electrolytic; the zinc is of 99·974 per cent., containing only traces of cadmium, lead, iron, copper, according to the analyses tabulated, in which the zinc per centage is marked "by difference," however. The cadmium is similarly stated to be of 99.912 per cent., the chief impurity being 0.052 per cent. of copper. The zinc is utilised for high-class brass and aluminium alloys (aeroplanes), cadmium for alloys of low-melting point (Wood's metal, &c.), and for the electro-plating and pottery industries. Pure ammonium salts and sulphur are other products of the firm.

The Cold Chemical Company (A. Landau), of Kingsland Road, N.1., makes a speciality of phosphorescent materials, all synthetic products in whitish or slightly-coloured powders. The zinc sulphide is the substance usually mixed with radium salts to give self-luminous compounds for watches, gun-sights, &c.; a new form of zinc sulphide is described as fluorescent; the calcium sulphide is also used on the field of war; the calcium tungstate and cadmium tungstate, as well as willemite (zinc silicate) serve for intensifying X-ray screens. Some of these compounds contain only traces of other constituents which seem to be necessary to give rise to phosphorescence; in others considerable percentages of bismuth or manganese are present.

Returning to the rare earths, we mention that according to Mr. Edward White, of Messrs. Hopkin and Williams, who lectured on the subject in the Exhibition, the trade in the monazite and thorium minerals of Brazil, Travancore, India and Ceylon

was practically under German control before the war. Mr. White proceeded to India in 1915, and the firm founded thorium works at Travancore and also a thorium nitrate factory in England; other firms have taken up the industry, which is now firmly established. Some 400,000,000 gas mantles are said to be now wanted annually. The monazite sand, which may be black with admixed magnetic iron ore, is largely cerium phosphate and contains also lanthanum and didymium; the chief thorium mineral, thorite, is a silicate. The most interesting exhibit in this branch is that of Sir William Crookes, who shows the pure white oxide of scandium (the metal has not been isolated yet), beautiful green crystals of scandium-platinocyanide, and photographs of the rare-earth spectra, as well as his antiglare-glasses and spectacles into the composition of which rare earths enter. Mr. J. H. Gardiner, Sir William's assistant, also alludes to a new secret war use of these earths in his article on the rare earths. Messrs. Melson Wingate (the Anti-Glare Glass Company) make a special show of these spectacles in the optical section. Various rare earth compounds are further exhibited by the London Thorium Company, and gas mantles by the Ramie Company, of Bradbury, near Stockport, and others.

Glass, Silica, Refractories, Laboratory Ware.—Considering that prior to the war only about 20 per cent. of the glassware used in this country was made here, that this consisted largely of common glass—we refer to optical glass below—that the furnace equipment was notoriously out of date, the belated revival of the British glass industry has been very successful. Thanks to the energetic efforts made by scientific bodies, the Glass Research Committee of the Institute of Chemistry, led by Sir H. Jackson, the Optical Munitions Branch of the Ministry of Munitions, under Mr. A. S. Esselmont, the new Society of Glass Technology, and especially by the manufacturers of chemical glassware, who combined to do all in their power to develop the industry, admirable results have been secured. Fortunately British glass sands were found to be better and more plentiful than had been expected.

As regards the development of refractory materials, the general position has continued to improve since the Faraday Society discussed the problems involved in November, 1916.* In writing on refractory materials in the catalogue, Mr. J. A. Audley draws attention to the powerful impetus given to the study of refractories by this discussion. Firebricks are made of clay, silica and magnesia. Some success has recently also been obtained with dolomite bricks, made from magnesian limestone, which is abundant in the country, whilst magnesite has to be imported. Other materials utilised as refractories are alumina (as corundum in the purest state, or alundum); fused bauxite (aluminium hydrate impure with iron oxide), bricks of which, it is hoped, will soon be available in this country; zirconia, an invaluable material, but still difficult for the manufacturer; chromite; carbon, for the separation of basic and silica bricks where combustion can be kept down; and carborundum, whose use has long since become very general. According to the Deputy Controller of Iron and Steel Production, Mr. W. J. Jones, the average output of refractories recently amounted to 200,000 tons per month, comprising 11,000,000 silica bricks and 500,000 magnesia bricks; the latter were not made here before the war.

Passing to particulars and to optical glass in the first instance, we need hardly say that the general remarks on the British neglect of the glass industry do not apply to the famous firm of Messrs. Chance Brothers and Co., of Smethwick, Birmingham, who have manufactured optical glass for more than 70 years and, while still supplying the old varieties of glass unsurpassed in quality either in Jena or Paris, have recently taken up new specialities of their own, that is to say, the outcome of their own researches. It is not superfluous to add that the formulæ and methods for the manufacture of glass for gun-sighting telescopes, field glasses, range finders, &c., are not, as has frequently been stated of late, the result of researches by the Institute of Chemistry; that Institute has done very useful work in chemical glassware, and also in optical glass, but the statement is derogatory to British science, and to firms like Messrs. Chance, whose original investigations go back many decades. The mistaken impression is partly due to a confusion between the new optical Jena glasses of novel compositions and properties previously unattainable, which created such a stir 25 years ago, and the heat-resisting Jena glass for the chemist and scientific apparatus generally, thermometers, &c. With the assistance of the Ministry of Munitions research laboratories have been fitted up at Messrs. Chance's works, but their manufacture of new optical glasses dates from pre-war time; their output of optical glass also for the Allies has increased twenty-fold. The types of optical glasses exhibited in rough lumps comprise borosilicate crowns, zinc crowns, barium crowns (light and dense), flints and barium flints (light and extra dense). They range in refractive index from 1.4785 up to 1.7566, and vary largely in dispersion. The moulded plates of reheated optical glass are made in cast-iron moulds; conspicuous among the polished glasses is a 28-in. crown disc, 3 in. thick, for an astronomical refractor. The heat-resisting glass globes and cylinders are for high and low-pressure incandescent lighting by gas or oil, inner cylinders for electric arc lamps, &c.

The Derby Crown Glass Company, of Little Chester, Derby, took up the manufacture of optical glass on the instigation of the Government; the exhibits show the optical glass in its pot, cracked with it in one instance, and the corrosion of the pot lining by the glass. The National Physical Laboratory does not contribute to the glass section. The Department of Glass Technology of the University of Sheffield, which was established in 1915, seems to be well equipped for its purpose, to judge by the photographs displayed. Various apparatus, a test-tube making machine, a blow-pipe with electric preheating of the gas and air, and a variable jet blow-pipe (all designed in the department) electric light bulbs blown of non-lead glass in the lampworking school, glass tubing, and also specimens of red and yellow selenium glasses, and of glass marked "optical" (lumps of translucent glass in various colours) are among the exhibits. The formulæ and tables of resistant power of various glasses to soda, caustic soda, and hydrochloric acid on the same stand are due to Sir H. Jackson. Professor P. G. H. Boswell, of Liverpool, shows a collection of exhibits illustrating his article on Glass-making and Refractory Sands in the catalogue.

Almost all the exhibits of chemical glassware are group exhibits of associations, comprising considerable numbers of firms. These are first the British Chemical Ware Association (16 firms, against six two years ago) and the British Flint Glass Association, of Stourbridge; the former Association also shows filter papers. The members of the British Lampblown Scientific Glassware Manufacturers' Association, which also supplies thermometers and barometers and surgical apparatus, are somewhat at an advantage in the exhibition, inasmuch as they have a room for themselves, and as the exhibits are displayed in horizontal cases or on tables, more convenient for examination than the other glassware is in the big vertical glass cases, and because the names of the manufacturers are specified. Great progress had undoubtedly been achieved in chemical glass and porcelain ware, as well as in thermometry, and the complex glass apparatus for fractional distillation, multiple-way taps, pipettes, hydrometers, &c., notably those by Messrs. Black, Son and Spencer; Calderara; Howard and Rawson; J. J. Hicks; J. Long; C. Muller, Orme and Co.; P. Stevenson; Negretti and Zambra, deserve mention. The British Laboratory Ware Association (17 firms) supplies, in addition to chemical glasses and appliances, also optical projecting apparatus, electric resistance furnaces for (temperatures up to 750 deg. and 1,000 deg. C.), Pensky-Martens flash-test apparatus, Soxhlet extraction apparatus, filter paper (from Messrs. Green, of Maidstone), and the Barthel burner for alcohol. This burner resembles a big Bunsen burner; the alcohol enters at the bottom of the burner through a flexible tube from the container under a head of about 5 ft., and the tap, about halfway up the burner, is a screw valve through which a jet of the alcohol escapes and evaporates.

Of other glass firms we mention Messrs. Ackroyd and Best, of Morley, near Leeds, (glasses for miners' safety lamps, Hailwas brand); Messrs. J. Moncrieff, of the North British Glass Works, Perth (laboratory and engineering glassware, and plants for munition works, cordite funnels, heat condensers, &c., miners' lamps, syphon discs); Messrs. Henry Richardson and Sons, of Wordsley Flint Glass Works, Stourbridge (chemical measures, bulbs, &c.); and Messrs. Wood Bros., of Barnsley (chemical and scientific glass ware). Messrs. Pilkington Bros., of St. Helens, show glass cells for accumulators and heavy stout glass plates for port-lights on board ship.

Of the exhibitors of silica glass, the Silica Syndicate, of Westminster, and the Thermal Syndicate, of Wallsend-on-Tyne, it is only necessary to say that satisfactory progress is being maintained. The former company shows transparent quartz glass which still retains the high melting point of quartz. The specimens of flasks, up to 4½ in. in diameter, vacuum vessels, elaborate apparatus, sample trays for assayers, and a little model of an aeroplane, about 4 in. long, well illustrate that the difficulties have successfully been overcome, however, and that any glass apparatus can be furnished in silica. The latter company produces a white, shiny variety of electrically-fused silica, resembling glasswool and china and known as "Vitreosil"; the heavy coils, pans, large tubes, and parts, some several feet in diameter, as well as boats, globes and small articles demonstrate the adaptability of the product.

In refractory bricks we notice one firm, the Cleveland Magnesite and Refractory Company, of Normanby, Yorkshire, who exhibit superior-looking silica bricks and blocks for the lining of and roofs of steel furnaces. The bricks are said to contain 95·12 per cent. of silica, 1·6 of alumina, 1·55 of magnesia, 0·99 of iron oxide, 0·27 of magnesia, 0·34 of alkalis, and to lose 0·20 per cent. on ignition; these figures would total up to 100·07. Magnesite bricks are not on view, only calcined magnesite. Temperatures in the furnaces are determined by Seger cones. Of the three brickworks of the firm two have been started since the war. The exhibits of Messrs. Moorcroft, of Burslem, exemplify the homogeneous fusion of the rare earths at high temperatures.

The "Vitreon" of Messrs. Shanks and Co., of Barrhead, Scotland, is a new product which this well-known firm has only made during the last two years. Vitreon is described as a vitreous, homogeneous, porcelain-like material, superior to stoneware, not dependent upon glaze; it is used, in fact, in acid plants, &c., both in the glazed and unglazed conditions. It is white, free of iron, resists heat well, and is mechanically strong; the compression strength is stated to be 24 tons to the square inch, the tensile strength 1,800 lb. per square inch, and a 2-in. pipe, ½ in. wall thickness, was not burst by an internal pressure of 900 lb. per square inch. The articles shown include large Buchner funnels (with false, perforated bottoms), dishes, beakers, receivers and absorbers with several necks, carboys (which stand shock better than glass does); pipes, bends 9 ft. in length, T-pieces, acid taps, picric acid pots, and nitric-acid plants. The headers of the Hart condensers are vertical stand pipes; two such headers, about 6 ft. high, 6 in. in diameter, ½ in. wall thickness, are fixed and interconnected by a large number of horizontal glass tubes, fitting into nozzles provided in the headers. The kieselguhr of the Diatomite Company, of Manchester, serves as filtration medium and for the manufacture of ultramarine, of tiles and bricks, &c.

Three novelties also concern glass and refractories. The "Delcoblast" of Mr. H. E. Davis, is a preparation for obscuring and frosting glass. The material is supplied in stoneware jars and is dissolved, best in boiling water; the lamp bulb to be frosted is dipped into the solution for half a minute, washed with hot water, and wiped with a sponge; it then appears as if treated with hydrofluoric acid or sand-blasted; the solution has no smell, and the frosting is not an incrustation which can be scratched off. The other novelties are pencils for marking glass, porcelain or stoneware, &c.

(To be continued.)

* See ENGINEERING, vol. cii, pages 464 and 489.

HYDRO-ELECTRIC STEERING GEAR OF THE S.S. "WULSTY CASTLE."

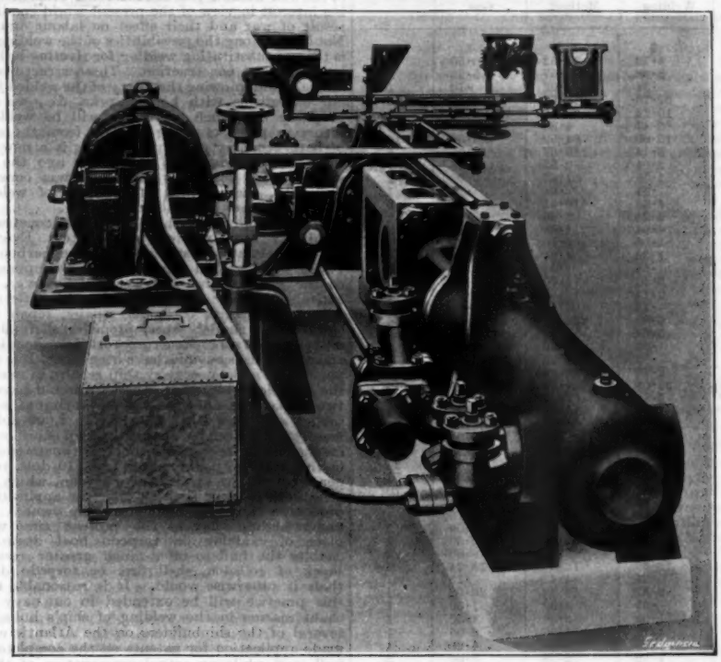
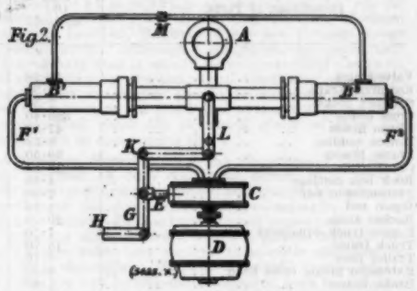


FIG. 1.



WE illustrate on this page the hydro-electric steering gear fitted to the ss. Wulsty Castle. It will be remembered that we gave a general account of the turbo-electric propelling machinery of this vessel in our issue of May 3, and that on July 12, July 26, and August 9 we followed with detail drawings and photographs of the steam turbines and electric generators. The steering gear constitutes an application by Hydraulic Gears, Limited (Hele-Shaw System), and has been constructed by Messrs. John Hastie and Co., Limited, Greenock. This arrangement was recommended for adoption on the Wulsty Castle by the naval architects, Messrs. Esplen and Sons, Limited, of Liverpool, after experimenting with other types of electric steering gear. From their experiments they concluded that it was necessary that the motor of an electric steering gear should run continuously, and should be protected from shocks by heavy seas. The general arrangement of the gear is well shown in Fig. 1, and its working will easily be followed on reference to the diagram, Fig. 2. In this, A represents the tiller fixed to the rudder stock, and B_1 and B_2 the hydraulic cylinders by which this tiller is operated. The Hele-Shaw pump at C is driven continuously by the electric motor D, but the flow from it is regulated by the spindle E, which is coupled up to the floating lever G. A full and detailed description of this pump was published in our issue of March 10, 1916, page 229, and it will, therefore, be sufficient to recall here that it consists of a set of plungers, working in radial cylinders, and having a stroke which can be varied at will. With the spindle E in the position shown in the diagram, the stroke of the plungers is zero; hence, the motor, though it continues to run, does no work. If E is pushed in, the pumps draw from B_1 by the pipe F_1, and deliver into B_2 by the pipe F_2, whilst, if the rod E be pulled out, F_2 becomes the suction pipe, and F_1 the delivery pipe, and the tiller is moved accordingly. One end of the floating lever G is coupled up by the link H to the tele-motor or control shaft from the steering wheel, and the other by the link K and lever L to the cross-head of the hydraulic ram. An "overtaking" motion is thus provided for the spindle E, which, as the tiller moves over in response to the action of the steersman, replaces F in its central position, throwing the pumps out of action. The two cylinders B_1 and B_2 are connected by a pipe, in which is placed a spring-loaded by-pass valve M. In the case of the rudder being subjected to a severe shock, this valve lifts and relieves the stress by allowing the rudder to move. In this motion the spindle E is carried over by the link work, and the pump immediately sets to work to restore the rudder to its previous position.

It is stated that the gear has proved very economical both in use and maintenance. The current required is generally provided from the electric-lighting set. The gear is extremely sensitive, and responds very quickly to the motion of the steering wheel. It has, moreover, the additional advantage of occupying but little space.

ELECTRIC ARC WELDING.*

By ROBERT E. KINKEAD.†

(*Concluded from page* 186.)

THE actual results of the operation of the welding equipment and the welding system on the Rock Island Lines have proven very interesting. We have recently undertaken a rather extensive investigation of what the results are, and I am giving overleaf some of the figures, we have obtained as a result of about six months' operation of the complete system. The real answer to the question of whether or not the expenditure of some 40,000 dols. for the installation of the system was justified lies in the actual facts—reduction of maintenance cost and actual gain in engine days with our present equipment. In other words, the object of the investigation was to determine whether or not we are saving money by the operation of the system, and whether or not we are actually getting more transportation service out of our motive power and rolling stock equipment. The table overleaf shows some actual figures on the cost of repairing a small number of representative locomotive and other parts (for which we were able to obtain costs at a reasonable expenditure) by the gas and electric method, as compared with the old method, which in many cases involves a complete replacement of the part. It is indeed unfortunate that the railways have not kept detailed costs of the work necessary to the operation of the property. As compared with the old method, the saving of the electric process arises principally in the saving in labour. As compared with the gas process, the electric welding offers a saving in the cost of producing heat and an appreciable saving in cost of labour. It seems that to me under present conditions, and possibly under conditions which will obtain in the future, the labour saving is the most important item. It is evident from the figures that an important saving has been made. In other words, the operation of the process in our shops may be said to have rendered each man more effective, and has enabled each man to accomplish more toward the maintenance of our equipment with the same amount of effort.

Our figures show that the saving effected by the electric arc welding system is being made at the rate of, approximately, 200,000 dols. a year with our present equipment. This figure includes a direct saving as compared with other methods of about 136,000 dols. The saving arising from the fact that we keep the engines in service a greater proportion of the time makes up the balance of the figure. This saving is being made at the rate of about 1,400 engine days per year.

Another way of looking at the same matter is that by the operation of the electric welding system we have obtained the service of four additional engines, without the additional investment, beyond that required to instal the welding system. Four additional engines are worth, approximately, 200,000 dols. The welding system installed complete cost about 40,000 dols. The cost of operation of the system for a year is, approximately, 34,000 dols. Figuring the value of the engines at 40 dols. per day, we will pay for the operation of the whole electric welding system, and will clear 22,000 dols. from this feature of the operation of the electric welding system alone. However, we made important savings, as are shown in the table overleaf, in the repair of parts on engines, where we could not show an actual gain in engine days of service, and this saving amounts to more than twice the saving arising in the increase of the number of engine days of service we get from our equipment. The net return secured on the electric welder investment amounts to, approximately, 500 per cent. per annum. The net cost of the installation and equipment per unit under present conditions is, approximately, 1,300 dols. The foregoing figures show rather conclusively that the installation of the electric welding system has been a profitable investment on the Rock Island Lines.

In spite of the fact that we have probably a larger number of operators than any of the Western roads, we believe that we are far from fully equipped. The field of application of the process is continually widening. We are not able at the present time to handle all the operations which we have demonstrated to be practical and profitable. There is a totally unexplored field of maintenance of freight and passenger cars, which promises to eclipse in importance maintenance of motive power. There is a field in the repair of special track work which we have not gone into up to the present time.

The present indications are very strong that when we go fully into the electric welding process in fire box boiler, locomotive, machinery, steel tanks, car work, track work, &c., that we can well use 150 units and effect a net saving, as I have stated before, of approximately, 1,000,000 dols. a year. Within the last three years the arc welding process has been greatly improved and developed, both in the equipment for making the weld and in the welding material. It has, in fact, been developed to such a state that it will, no doubt, cause changes in many forms of construction, and the welding of fire boxes, tanks, &c., will become an economical practice. In fact, it is in the car field of construction and maintenance that we may look for a wonderful development. For instance, to-day the cast-steel truck side frame will last almost indefinitely where the electric welder is used in maintenance. Also it is as a preventative that the electric welder has a great field by the intelligent application of spot welding with the electric arc. It will, no doubt, be possible to tie down bolts and nuts in the various parts of the rolling stock and motive power in such manner as to prevent their working loose, with the attendant very large saving in maintenance and operating expense. Quite recently we have been able, by using what is called a slag-coated electrode, to deposit steel having a carbon content of 0·50 per cent. which will enable us to do some work which we have been unable to do heretofore. We can successfully take care of the worn or damaged flanges of driving wheels, and should be able to reclaim much of the special work and rail steel by successfully building up the worn parts or broken sections.

It has been our purpose in establishing the practice in the welding field to look the facts squarely in the face and apply either the gas or electric process, depending on which shows the best results at the lowest price. At the present time we are of the opinion that the electric process will supersede the gas process on all steel welding and some of the rough-steel cutting. In the cutting of boiler steel and all close cutting, however, and the welding of cast-iron and the non-ferrous metals, the gas process has unequalled advantage. We are operating 75 gas torches and one acetylene generating plant on the same general principle as obtained in the case of the electric arc welding equipment. It is also best to use gas welders at all points where only occasional welding is done and which would not justify the investment necessary for the installation of electric welder.

While we have not been able to meet the suggestion of the American Railway Association's Special Committee on National Defence, which reads as follows: "About 15 per cent. of locomotives are ordinarily under repair. If this percentage were reduced to 10 per cent., which figure has been reached by some roads, it would mean an addition of 3,325 locomotives to the number in

* Paper presented to the Cleveland (U.S.) Engineering Society, December 11, 1917.

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TABLE I.—Comparison of Electric Welding *versus* Old Methods and Gas Welding.

Description of Parts.	Cost Old Method.	Cost Gas Welding.	Cost Electric Welding.	Saving Over Old Method.	Saving Over Gas.	No. Engines.
	$	$	$	$	$	
Valve stems	16·28	15·26	4·76	11·52	10·50	6
Eccentric straps	17·95	7·63	2·38	15·57	5·25	2
Cylinder cocks	1·38	·104	·34	1·02	·70	1
Cross heads	356·40	120·23	37·73	318·67	82·50	13
Piston heads	47·93	52·74	10·24	37·69	22·50	4
Motion saddles	8·32	10·94	3·44	4·88	7·50	2
Frame braces	99·50	48·00	15·00	84·50	33·00	10
Crank arms	18·81	20·14	8·14	10·67	18·00	5
Rock box castings	4·59	7·29	2·04	2·55	5·25	1
Transmission bar	2·80	4·38	1·38	1·42	3·00	2
Reach rod	1·25	1·09	·34	·91	·75	1
Rocker arms	20·75	13·24	4·24	16·51	9·00	6
Engine truck equalisers	7·70	17·24	5·24	2·46	12·00	2
Truck frame	15·70	13·04	4·04	11·66	9·00	3
Trailer jaws	2·76	4·38	1·36	1·40	3·02	1
Extension piston cross head	6·30	4·36	1·36	4·94	3·00	1
Brake beams	1·69	2·18	·68	1·01	1·50	1
Brake hangers	5·10	7·45	3·40	1·70	4·05	3
Smoke arc brace	3·50	6·25	2·14	1·36	4·11	1
Air pump valves	2·50	1·33	·53	1·97	·80	1
Lugs on valve yoke	32·45	21·80	6·80	25·65	15·00	6
Push-car wheels	6·00	10·56	3·05	2·94	7·50	4
Stillson wrench	1·80	1·09	·34	1·26	·75	1
Drill chuck	15·00	2·18	·68	14·32	1·50	1
Driver brake fulcrum	5·52	8·72	2·72	2·80	6·00	1
Wheel spokes	1,276·80	113·08	35·08	1,241·72	78·00	15
Main-rod blocks	15·88	28·34	6·84	7·04	19·50	9
Triple valve gauge	20·00	3·27	1·02	18·98	2·25	1
Link blocks	72·24	51·49	15·49	56·75	36·00	20
Lift shafts	23·98	4·02	1·02	22·96	3·00	1
Quadrant	7·43	11·09	3·59	3·84	7·50	3
Wedges	55·04	69·69	21·69	33·35	40·88	25
Chafing castings	8·30	10·70	3·20	5·10	7·50	1
Plugging and building up holes	349·69	280·94	140·47	209·22	140·47	70
Tire rim keys	3·22	5·38	2·38	·84	3·00	2
Throttle stem	1·50	1·09	·34	1·16	·75	1
Reverse lever support	3·38	4·36	1·36	2·02	3·00	2
Smoke box	61·38	32·43	9·93	51·45	22·50	2
Hub liners	12·51	13·11	4·11	8·40	9·00	3
Strip on cross heads	25·32	31·00	12·66	12·66	18·34	3
Fire door handle	1·75	1·09	·34	1·41	·75	1
Boiler casings	63·21	30·30	9·32	53·89	20·92	1
Frame buckle	4·90	2·41	·91	3·99	1·50	1
Trailer yokes	5·25	6·45	1·95	3·30	4·50	1
Motion frame	9·10	10·17	4·17	4·93	6·00	1
Combination lever	1·03	1·75	·55	·48	1·20	1
Lugs on trailer hub	4·50	4·52	1·52	2·98	3·00	2
Centre castings	76·81	28·56	9·06	67·75	19·50	3
Spring blocks	1·15	1·09	·34	·81	·75	1
Guide blocks	5·52	4·29	1·29	4·23	3·00	1
Binder	5·19	13·10	4·10	1·09	9·00	2
Steam pipes	3·79	5·12	2·12	1·67	3·00	1
Flat spots on tyres	99·86	95·77	29·77	70·09	66·00	4
Cylinder bushings	35·65	9·40	3·40	32·25	6·00	1
Building up side rods	93·48	81·16	31·16	62·32	50·00	2
Grease cups	11·79	11·43	3·93	7·86	7·50	5
Stationary fire door	8·00	8·72	2·72	5·28	6·00	1
Cracks in tanks	372·69	113·62	35·16	337·53	78·46	14
Petticoat pipes	140·52	52·37	16·37	124·15	36·00	18
Filling worn spots	2,677·80	1,064·66	329·60	2,348·20	735·00	128
Pins	70·66	87·23	27·23	43·43	60·00	27
Reverse lever parts	103·02	74·04	23·04	79·98	51·00	38
Total	$6,434·10	$2,755·74	$921·61	$5,512·49	$1,834·13	

TABLE II.—*Comparison of Electric Welding* versus *Other Methods.*
Parts that cannot be Welded by Gas.

Description of Parts.	Cost of Other Methods.	Cost of Electric Weld.	Saving.	No. Engines.
	$	$	$	
Pedestals	645·00	45·24	599·76	5
Tank frames	9·03	1·36	7·67	1
Shop tools	34·36	3·40	30·96	4
Piston rods	78·64	16·37	62·27	10
Sharp flange drivers	165·40	20·28	145·12	
Truck side	194·00	10·20	183·80	4
Building up dr. axles	121·50	4·90	116·60	1
Steel car underframe	11·34	1·71	9·63	1
Building up car axles	315·00	25·24	289·76	—
Bushing staybolt holes	294·96	73·74	221·22	26
Welding flues	2,607·65	521·53	2,086·12	192
Frames	931·00	133·28	797·72	11
Cracks in the fire boxes	2,431·27	297·17	2,134·10	92
Total	$7,839·15	$1,154·42	$6,684·73	

TABLE III.—*Summary.*
Costs and Savings—Per Month.

Cost of Other Methods.	Cost of Gas Welds.	Cost of Electric Welds.	Saving Over Other Methods.	Saving Over Gas Weld.
$	$	$	$	$
6,434·10	2,755·74	921·61	5,512·49	1,834·13
7,839·15	3,697·42*	1,154·42	6,684·73	2,543·00*
14,373·25	6,453·16	2,075·03	12,197·22	4,377·13

Costs and Savings—Per Year.

Cost of Other Methods.	Cost of Gas Welds.	Cost of Electric Welds.	Saving Over Other Methods.	Saving Over Gas Weld.
$	$	$	$	$
77,205·20	33,068·84	11,059·32	66,149·88	22,009·56
94,069·80	44,369·04*	13,853·04	80,216·76	30,516·00*
171,279·00	77,437·88	24,912·36	146,366·64	52,525·56

* Figures show cost of gas weld if work could have been welded with gas.

service," we have been able to move in that direction and have nearly reached the figure of 10 per cent., and at the same time added to the profits of the road by our welding system. It is our belief that with approximately five times the amount of electric welding capacity we have at present, we can show at least five times the annual net saving, which would amount to 1,000,000 dols. a year, and that we can with this equipment in operation, show a saving of around 7,000 engine days per year, which means that we would be able to secure from our present engines a mileage that will equal that which could otherwise only be secured by the purchase of 23 additional engines.

With this figure in mind, and knowing that the Rock Island Lines have, approximately, 1,600 locomotives in service, it is easy to realise the enormous possibilities in the direction of increasing the service from motive power equipment on the combined railway systems of the nation, both as an economic proposition and as an aid in war, were they all equipped with welders. The demand for transportation service is so urgent, and the effectiveness of the nation in this war depends so directly upon the quantity of service which may be rendered, that it seems imperative that the railroads should go into the welding field on a large scale at the earliest possible moment. These figures have been given with particular reference to motive power units. While we have no tangible data on what may be accomplished in the rolling stock field, it is our belief, from the preliminary survey of the situation, that even a greater gain can be made toward keeping the equipment in service in this field than has been made on the motive power units.

The application of the new welding processes is important now as never before, when every railroad must get the maximum of service from all of its equipment; when the nation demands the supreme effort of the transportation system of the country.

What I have just said refers particularly to railroad work and gives some idea of what we think can be accomplished, using as a basis for estimation the results we have actually accomplished on the Rock Island Lines. The enormous possibilities, however, in the application of the new welding processes to other fields are of absorbing interest in view of the present world conditions as a result of war and their effect on labour and material. Not least among the possibilities of the welding processes is that of substituting welding for riveting in bridge and building steel construction. These structures are permanent, and knowing the safety of the welded joint, from our experience with boiler works, &c., we can safely prophesy that such structures will be welded in the future in place of being riveted, from the standpoint of both economy and safety. This is a new idea, but when we consider that five years ago the complete welding of a locomotive fire box was considered an absurdity, the newness of the idea of welding steel structures is not in the least appalling.

The possibilities in the field of ship construction and repair have been explored to some extent. Every harbour on the Atlantic coast and the large harbours on the Pacific coast are all equipped with the apparatus. Up to the present time the welding, however, has been entirely on repair work, but the savings effected by the use of the process on boiler repairs, repair of broken stern posts, rudder shoes, propeller shaft sleeves and miscellaneous super-structure work, have been important, and enormous economies have been made. It is sometimes possible to make necessary ship repairs in one day with the electric welder that otherwise would have required two weeks, and since the value of a ship at sea per day ranges anywhere from 500 dols. to 2,000 dols., it can readily be appreciated that there is an enormous demand for the work at the present time. The commercial welders in the Atlantic ports charge from 10 dols. to 20 dols. per hour for the services of one man, which is a very good indication of the fact that the application of the process is valuable to the steamship owners. It is the understanding that at the present time welding in place of caulking on torpedo boat destroyer hulls enables the hull to offer much greater resistance to shock of collision, shell fire, or torpedo destruction than it otherwise would. It is reasonable to assume this practice will be extended in our navy and merchant marine in the welding of ship's hulls. Already several of the shipbuilders on the Atlantic coast have made application for patents on the completely welded hull, and while no actual construction of this nature has been done as yet, it is probable in the near future that we shall see the completely welded hull in service.

The extensive application of the arc welding process in the United States has led other countries to the adoption of the improved practice. Notable examples of this are the introduction of welding outfits into the principal harbours of the South Atlantic. In the German and English naval engagement off the Falkland Islands, the British ships were severely damaged and put into a port for repairs, where they obtained a marine electric welding outfit, immediately putting to sea and effecting their repairs in a comparatively short time; thus their ships were ready again for service in a much shorter time than would otherwise have been possible, when every minute was very valuable indeed.

The electric welding equipments were extensively used in repair work during the construction of the Panama Canal. The South American Railway Corporation and some mining corporations are installing the portable equipment manufactured in this country. A Japanese government expert has recently returned to Japan with complete information and the introduction of the process will probably be rapid in that enterprising country. Already a considerable amount of equipment has been shipped to Spain, Norway and Sweden for use on railways and in steel foundries.

Four portable electric arc welding units such as are in use on the Rock Island Lines are now being shipped to the French fighting front for use on military railways by the "American engineer regiments (railways)." The application here covers not only the standard gauge railways which transport ammunition and supplies to the front lines, but also in the construction and maintenance of narrow-gauge feeder and trench railways, the tracks of which are ordinarily constructed of small steel rails which may be welded to the steel ties, these railways being of a portable type. There are also a very large number of automobiles, motor-cycles, &c., to be repaired, as they are constantly breaking down, due to the extremely strenuous service in which they are employed. In fact, without the use of the gas and electric welders, the life of such equipment would be very short indeed, when used at the battle front. Within the last year we have seen the increasing use of the English tanks, which call for very extensive repairs, that can be most efficiently made with the electric welder. The artillery also makes a heavy demand on the welders for repairing gun carriages, gun mechanism and the guns themselves. It is necessary on the front that these repairs be made expeditiously under most trying conditions—conditions that it would be practically impossible to meet were it not for the autogenous welding devices.

A little to the rear of the actual fighting front, the electric welders are in demand for repairing horse equipment, including the repairing of vehicles, and it is thought that in the near future it can be used for welding new calks on the horse shoes to replace those that are worn, without the necessity of removing the shoe from the horse's hoof. The strenuous military campaigns require frequent demolition of iron and steel structures, including heavy guns, and the electric and gas cutting processes have been found extremely valuable owing to the great speed at which iron or steel structures may be demolished beyond the hope of repair.

In many instances there is a source of electric power

supply from the power lines that run in or through the theatre of war. However, in some instances where no such lines are encountered and for some reason or other it is not possible hastily to construct a power line, it becomes necessary to set up a small internal-combustion, power-driven unit in order to secure an electric power supply, which is becoming a necessity in modernised warfare. Electric welders can be used for trench lighting and searchlight work as well as for welding, which makes them very valuable equipment. One of the particular advantages in using the electric welder is that it eliminates the necessity for transferring welding gas, which would many times be practically impossible.

The final result of every effort must be to put effective fighting men in the field because it is increasingly evident that the war will be won by the men who go over the top and put the enemy out of business, by exterminating him. It is easy to lose sight of the fundamental facts in this connection by a lot of superficial talk about the economic side of the war. We are so far removed from the active fronts that it is easy to lose ourselves in a lot of talk about industrial economics and about how food will win the war, how locomotives will win the war, how sugar will win the war, how torpedo boat destroyers will win the war. It is easy to forget that it is actually the fighting man-power we can bring to bear upon the enemy that will really be the deciding factor. We must have the greatest possible industrial efficiency that can be obtained regardless of cost, regardless of the effort required to obtain it, and the reason is that we have fighting men on the front who must have everything that is required to keep up their moral and keep them in the very highest degree of effectiveness. Industrial efficiency is a part of our job, a necessary part of the nation's job of backing up the armed forces in the field. The big job is done by the men who go over the top or over the seas and exterminate the enemy.

Another interesting application of the electric arc process is in the repair of the ships. Every ship that is seaworthy is in service at the present time, and time for repairs must be cut to the irreducible minimum. The electric arc process is used extensively for boiler repairs and repairs about the deck and superstructure. It is not unusual to make repairs to a ship's boiler with the electric arc process in 24 hours while a ship is unloading her cargo which otherwise would require a week to ten days to make and fifty times the cost. The use of the oxy-acetylene and the electric arc processes on the ex-German ships which were badly smashed up by the Germans, allowed these ships to be put into the service of the United States from four to six months sooner than would have been possible otherwise.

In the steel foundry the electric arc process is used to repair defects in steel castings which would otherwise make the casting useless. At the present time, the demand for steel castings for the government is greater than all of the steel foundries of the country can supply. The labour conditions in this industry are generally in such conditions that it is impossible to get sufficient highly-skilled labour to make perfect castings. The net result of the use of the welding process is to get the same output of castings as if all the men were skilled craftsmen.

The electric arc process is being used in boiler shops to replace riveting, a seam may be welded cheaper than it can be riveted and the joint is stronger than it is possible to obtain with the riveted construction in making a joint. One man with an electric arc will do as much work as a riveting gang of four men and the electric power required to operate the electric welder is about the same as the power required to run a pneumatic hammer.

Another interesting application in the process is in oil refineries where it is used both in addition to riveting and in place of riveting. On some of the large stills whose operation must be as nearly continuous as possible, the riveted joints are welded instead of being caulked. Such a joint is stronger than the original plate and the life of such a still is more than doubled.

PENNSYLVANIA RAILWAY STANDARD ROUNDHOUSE.—We read in the *Iron Age* that the Pennsylvania Lines West have adopted a standardised type of construction for engine terminals. The frame of the round-house will be of steel with reinforced concrete roof over the 75-ft. cranes. Each roundhouse will include a complete smoke exhaust and washing system, shop buildings and other facilities. The first round-house of this type will be erected by the Austin Company, Cleveland, at Crestline, Ohio. This will be a 30-stall house costing about 500,000 dols; it is to be completed in 120 working days. It is expected that a similar unit will be erected at Richmond, Ind., in the near future.

QUEENSLAND'S COAL RESOURCES.—The coal deposits of Queensland are amongst the most important mineral features of the State, not only as regards the extensive area they occupy, but also in respect of their commercial value. The Ipswich coal field, 25 miles from Brisbane, occupies 12,000 sq. miles. By far the greater proportion of the coal wrought in Queensland has been and still is obtained from that field. But experts say, that in an economic point of view, the most important field of palæozoic coal is the Burrum, 15 miles north-west from Maryborough, and one or two of the deeper bores on this field seem to indicate that the deeper seams of coal are more anthracite in quality than those near the surface. The quantity of coal won in the State during 1915 was 1,024,273 tons, valued at 409,342*l.*, the average being 7*s.* 11*d.* per ton. There were 27 collieries working in the Ipswich district during the year, 7 in the Darling Downs district, 1 in the Central district, and 4 at Blair Athol. An increased quantity was obtained from the Mount Mulligan mine.

PUBLIC FINANCE AND ENGINEERING.

THE report of the Committee of Public Accounts (a different committee from that on national expenditure) gives the following information.

Shipbuilding.—In the absence of competition, the Admiralty adopted a new form of contract based on net cost plus establishment charges, with a profit of 10 per cent. on the estimated cost and a bonus of 10 to 20 per cent. on the amount by which the actual cost proved less than the agreed estimated cost. The establishment charges are taken on one of two bases: either a percentage (the report does not say on what) or as ascertained by the Admiralty. This system has been modified further by transferring to establishment charges certain fixed amounts not bearing any relation to actual or estimated cost. The nature of these fixed amounts is not stated.

Superintending Engineers.—In the erection of the Royal Naval Cordite Factory the remuneration of the superintending engineers, constructional and mechanical, was fixed on a percentage basis, presumably percentage on cost. The total cost of the work greatly exceeded the anticipation and, at their own suggestion, the remuneration of the engineers was reduced. The committee remark that the Admiralty should have fixed a maximum.

Munitions Ministry.—The total expenditure is stated to be:—

	£
Year ended March 31, 1916 ...	222,000,000
" " 1917 ...	502,595,000
" " 1918 ...	620,000,000
	£1,345,000,000

This, however, does not represent the full expenditure but only the amount charged to the parliamentary vote. Any items of increase of a Government department, such as sales of products scrap, waste, &c., are entered in its accounts as "Appropriations in Aid." The theory is that all departments are services and not businesses; and all expenditure is paid by the Treasury and all income is due to the Treasury. Nevertheless, certain items are intercepted or "appropriated" by the various departments. Against this expenditure the Ministry had certain assets on March 31, 1918, as follow:—

	£
Fixed capital	40,000,000
Stocks at cost price	240,000,000
Loans, metals, &c.	70,000,000
Stocks held by the Army ...	100,000,000
Total	£450,000,000

The Committee refer to these as "existing assets, many of which, however, are essentially wasting in character." The value of the fixed capital has been "calculated with a heavy depreciation." In the same report the committee mention 66,000,000*l.* as the capital expenditure on the national factories so that the rate of depreciation is at least as 26 to 66 in. say, on average of two years, or about 20 per cent. per annum. This may be compared with the 5 to 7½ allowed to private firms by the income tax authorities on machinery only and the smaller rate (hitherto *nil*) on land and buildings which are included in the fixed capital of the national factories.

Aircraft Supplies.—Contracts are placed on the fixed price system and also of the cost plus percentage system—the latter being altered to the former as soon as possible.

Steel Rolling Mill.—The capital expenditure, originally 630,000*l.*, is now estimated at 1,200,000*l.* In accordance with a new general rule any item of capital expenditure exceeding 50,000*l.* will be submitted to the Treasury for sanction before expenditure begins.

Canal Works.—The Inland Water Transport Department commitments for expenditure since 1916 is given as follow:—

	£
Original schemes by Treasury sanction	109,000
Further expenditure without sanction	822,000
Omitted liabilities which "came to light"	130,000
Additional estimates, &c.	350,000
Cost of military labour at 8*d.* per hour hour per man	500,000
Estimated total	1,911,000

The rest of the report is taken up with general financial criticisms in the course of which it is stated that from April 1, 1918, the Ministry of Munitions will start "a complete new system of account, approved in outline by the Treasury.

MINERAL RESOURCES OF BURMA.—We read in the *Bulletin of the Imperial Institute* that broad tracts of ferruginous laterite are found in many parts of Burma, some of which have been worked for iron in the past; but imported iron is cheap, and iron ores have never had any economic importance in the province. Coal is found in Thayetmyo, Upper Chierdwind Shwebo, and Mergui districts, and in the Shan States. The Burmese, having abundance of wood within easy reach, have never utilised coal as a fuel. Burma has a very large wealth of petroleum. Tin stone has long been worked in Tarcy and Mergui districts. It is found in granite and also in alluvial deposits. The mine workers are mostly Chinese. The Burma Corporation's mine at Bawdwin in the Northern Shan States is the only important source of lead and silver in Burma. The methods of working wolfram, which before the war amounted to little more than surface extraction, have been improved.

CATALOGUES.

Electric Motor Starters.—Hand-starting rheostats for motors of ¼ h.p. to 40 h.p. are the subject of a special catalogue received from the British Thomson-Houston Company, Limited, Rugby. These are for continuous current motors. Although a simple enough mechanism it is necessary that it should be very carefully designed, and made to meet the usage and conditions of average work. Such catalogues should be carefully read and filed for reference. A great deal of loss still arises from the imperfect condition in which many of these are found, even in engineering shops.

Locomotive Superheaters.—The Superheater Corporation, Limited, 14, New Burlington-street, W. 1, send a fully illustrated and descriptive catalogue of the Robinson superheater for locomotive boilers—suitable for any fire tube boiler. In this type the wet steam collects in a distributing chamber from which it passes through the superheater tubes and returns to another chamber on its way to the engine. The tubes are bent over to nearly parallel, the two forked ends connected each to different chambers in the header and the folded end projecting into a fire tube. The illustration shows about 24 to 28 such tubes on a locomotive boiler. The arrangement has several variations. Special steam valves are shown in the catalogue and also tools for inserting and extracting the tubes.

Steel Treatment.—The various alloy and high-speed steels are delicate and unstable when at critical heat, and tools which have cost much in material and labour may be spoilt, or greatly reduced in efficiency, in the heat treatment process. Perhaps the greatest practical difficulty is in getting the required heat throughout the body of the tool without burning the light projecting parts. The workman has to avoid heating the tool so slowly that it amounts to "soaking"—which is nearly as bad as burning. Messrs. John Wright and Co., Aston, Birmingham have given special attention to the selection of various salts which are used to provide baths giving the required temperatures for heating and quenching various steels. A pamphlet issued by this firm, giving the trade names and describing the purposes of a series of these salts, is worth careful attention. Salt bath furnaces are shown in several forms.

Shipbuilding Gear.—A catalogue from Sir William Arrol and Co., Limited, 56, Victoria-street, Westminster, S.W. 1, illustrates the giant mechanical equipment for shipbuilding, made by the famous Scotch firm, by which the various parts from keel plate to upper deck pieces are lifted, travelled and laid in place. Pillar cranes, stayed at the top, with jibs. Scotch cranes for comparatively low lifts. Pedestal cranes with level and inclined balanced jibs. Gantry travelling cranes of great height on rails which span two railway lines. Finally, a series of permanent frameworks which span one or two slipways for the largest ships and carry numbers of small wall cranes and several powerful travelling cranes. Everything is worked out for rapidly lifting and transporting and placing the pieces accurately for building. Electric power is chiefly used. These structures are familiar in many English and Scotch ship yards and in the Ulster yards. The catalogue is printed in French for general foreign circulation.

THE MODEL FABRICATED SHIP.—The first of the national fabricated ships designed by a committee of shipbuilders, which was recently launched by Messrs. Swan, Hunter and Wigham Richardson, Limited, is 411 ft. 6 in. long, 55 ft. 5½ in. broad, 38 ft. 1½ in. deep, with a deadweight carrying capacity of 10,500 tons on a draught of 28 ft. 3 in. She is now being fitted with ordinary triple-expansion engines, and will have three boilers, each 15 ft. 6 in. by 11 ft. 6 in. She is the pattern vessel for ten others which are to be constructed on the fabrication system with the aid of bridge-building works, and from her all moulds and templates have been supplied to the bridge builders for reproduction of the fabricated parts ready for erection in national and other yards. The object has been to utilise the available plant and labour of bridge-builders, which called for the simplification of both structure and form. As bridge-builders are unable to deal with curved surfaces a "straight line" form was evolved, the curved forms of usual construction being eliminated as far as practicable. There is not a single bent frame in the ship, and all the plating, except some, of course, at the fore and after ends, is straight. Thus the bending of frames is rendered unnecessary, and the rolling of plates for "twist" and form is appreciably reduced. A good deal of additional work was involved in the design of the ship, but now that the first of the type is in the water, the duplicated parts will greatly facilitate the building of sister ships. The hull was constructed in 5 months, delay being caused by an epidemic of influenza and the incidence of the Tyneside annual holidays. The next ship will be built much more quickly. None of the material in this first ship is from the bridge-builders, but now they will come rapidly into production. The material can be accumulated as desired, and construction will proceed more speedily than ever before. The multiple punching machine was used to a greater extent on this vessel than hitherto, and was very successful, making good holes. All the spacing of the rivets was carefully worked out so that plans and wood templates could be made and sent to the bridge-building firms without delay for reproduction. The time and labour spent in perfecting this design is expected to yield handsome results. Minor improvements will come with experience, but the broad principle of the design has been worked out so successfully in the experimental ship that the pattern is likely to stand.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

115,895. British Insulated and Helsby Cables, Limited, Prescot, G. E. Bairsto, South Farnborough, and H. H. Harrison, Knotty Ash, Liverpool. Loading Coils for Telephone Circuits. (3 *Figs.*) May 21, 1917.—The present invention relates to an improvement in loading coils as employed in duplex telephony for loading simultaneously the phantom and physical or side circuits, and particularly of one of the coils described in Specification No. 22,554 of 1914. In the use of such loading coils there is experienced a defect, giving rise to cross talk between the various circuits of the combination, when any out-of-balance quantities exist. In accordance with the present invention, the defect above alluded to is avoided by the application of the principal of subdivision of windings to coils used for simultaneously loading physical and phantom circuits. The improved coil is constructed as an elongated core in the form of a closed geometrical figure, *e.g.*, in the form of an elongated annulus or ellipse A, traversed by several other cores B, C, D, so spaced as to obtain magnetic symmetry, *e.g.*, spaced equally apart

Fig. 1.

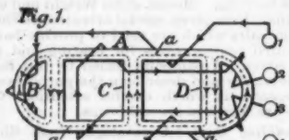
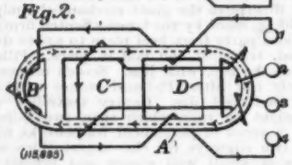


Fig. 2.



and disposed parallel to the minor axis of the figure. The magnetic circuit is built up of iron laminæ or stampings electrically insulated from one another and forming, when assembled, the annulus A. The windings are so arranged that those on the opposite sections of the iron core belong to the same line of a physical circuit and adjacent windings belong to different lines of the physical circuit. Also, the polarity of all windings is in the same sense with regard to the elongated core. The two component physical circuits are indicated by the lines 1 and 2 and 3 and 4 respectively. The conditions being as stated, currents due to the physical circuit will produce a circular flux through the transverse limbs as indicated by the character *a*, while currents due to the phantom circuit will produce a circular flux circulating through the core forming the boundary of the figure as shown in dotted lines in Fig. 2. The transverse limbs B, C, D, should be of twice the sectional area in the core constituting the boundary of the figure to accommodate the two separate sets of magnetic lines of force which have to pass through them. (*Accepted June 5, 1918.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

115,987. Straker-Squire, Limited, London, and O. D. North, Chelsea, London. Lubricating Crank-pins. (4 *Figs.*) August 13, 1917.—This invention relates to apparatus for lubricating crank pins comprising a scoop fixed to the end of the crank-pin and means for introducing lubricant into the path of the scoop. The crank-pin *a* is formed with a flat stepped face *b* at one end, to which face is fitted a correspondingly-shaped face of the scoop *c*, the latter being fixed in place by screws

Fig. 1.

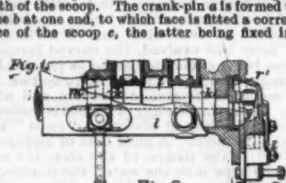


Fig. 2.

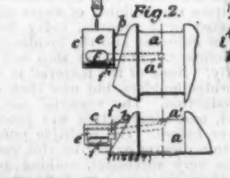


Fig. 3.

or otherwise. The scoop travels in a circle having its centre in the axis *d* (Fig. 3) of the crankshaft and is of such shape that its cross-section is a portion of a segment of this circle. Thus the scoop has an outer cylindrical face and an inner flat face *e*. In the flat face *e* is a cavity *f* in which opens a bore *f1* registering with a bore *a1* in the crank-pin. In Fig. 3 the scoop *c* is about to receive a drop of oil on the face *e* which will find its way into cavity *f* and thence, owing to centrifugal force, through the passages *f1*, *a1*, to the surface of the crank-pin. According to this invention, such a system of lubrication is combined with new apparatus for lubricating crank pins, by boring a tunnel or tube at the bearing of the shaft and fitting in the bore a pipe through which oil passes to the path of the scoop. The hollow camshaft *i* having journals *k* rotates in a tube *l*. In each of as many journals as may be required there is a radial bore *m*, and as the shaft rotates this bore registers with a pipe *n* screwed into a bore in the wall of the tube *l* and extending through the wall *o* of the crank-case. Oil is pumped into a chamber *w*, whence it finds its way through perforation *y* in the disc *r1* into the axial bore of shaft *i*. It being preferable that at the moment when a radial bore *m* registers with pipe *n* the full pressure head under which the oil exists in the hollow shaft *i* should be available for ejecting oil, the several bores *m* in the several journals *k* of the shaft *i* are angularly displaced relatively to each other around the axis of the shaft, so that no two bores *m* register with their corresponding pipes *n* at the same time. The oil should preferably drop uniformly into the path of the scoop, and to this end the jet *p* is radially bored so that the pressure on the oil is relieved and the flow is determined by gravity alone. (*Accepted June 5, 1918.*)

115,997. Goodhall, Clayton and Co., Limited, Hunslet, Leeds, and T. Settle, Leeds. Coal-Gas Manufacture. (2 *Figs.*) September 7, 1917.—In accordance with this invention, a retort is steamed in a downward direction on the distillation of the coal being completed and the water-gas thus formed by the incandescent charge of coke is admitted, after passing through a superheating box in the retort setting, to a newly-charged retort in an upward direction, the admission being continued during the early periods of distillation and longer if required. *a* are vertical retorts arranged in a brickwork setting *b*. *c* is a highly-heated chamber communicating with all the retorts near the bottom by means of ducts *d* furnished with valves *e*. *f* is the hydraulic main communicating with all the retorts *a* by means of pipes *g* provided with valves *h*. *i* is a superheater arranged in the brickwork of the setting. *j* is a pipe leading from the steam superheater *i* and communicating by branches *k* with all the pipes *g*. *l* are valves between the steam pipe *j* and the pipes *g*. *m* are ordinary flues (see Fig. 2) in the brickwork leading to the chimney. *n* is a deck arranged above the setting. In operation, one retort is charged

Fig. 1.

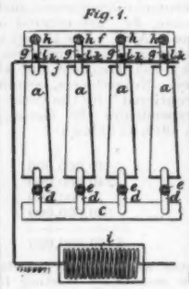
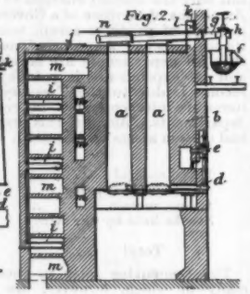


Fig. 2.



and partly burnt off. After a suitable delay the valve leading from this retort to the heating chamber *c* is opened and the valve leading from chamber *c* to another retort, which is newly charged with coal, is opened, all communication between the chamber *c* and the other retorts being closed. At the same time superheated steam is admitted to the first retort at the top, passes down through the charge carrying with it such of the gases as remain in it into the chamber *c*. In this chamber the water-gas from the first retort receives additional heat, and from thence it passes into the second retort, traverses the same in an upward direction and escapes by the opened valve *h* into the hydraulic main *f*. All the valves *h* and *e* belonging to retorts not for the time in operation are closed. When the charge in the second retort has been distilled long enough and the first retort has been used up, steam is admitted into the top of the second retort in the same manner as before described in connection with the first retort, and the third retort is connected up through the chamber *c* with the second retort, and so on throughout the whole system. (*Accepted June 5, 1918.*)

116,068. Robert Dempster and Sons, Limited, Elland, and R. M. Brooke, Elland. Hydraulic Mains. (5 *Figs.*) April 16, 1918.—In hydraulic mains used in coal-gas manufacture where the draining connections between the hydraulic main and the tar main are at right angles or approximately so, these angles interfere with the easy flow of the tar and are liable

Fig. 1.

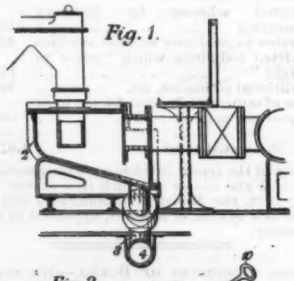
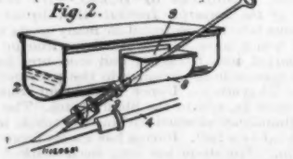


Fig. 2.



to cause obstructive accumulations at the junctions. According to the present invention, the connecting pipes 3 are placed at acute angles with both the hydraulic main 2 and tar main 4 so that a cleaning rod 10 can readily be passed through from the hydraulic main or side lute or side-box 8 into the tar main and push the obstruction past the next branch, and so on until the end of the tar main is reached. In the case of hydraulic mains 2 having a continuous lute and sloping bottom, Fig. 1, the draining pipe 3 can be led from the said sloping bottom under the lute, and in other types of hydraulic main a special box 8 with a movable cover 9 (Fig. 2) is provided, preferably on the side of the hydraulic main, for the purpose of enabling the pipes to be cleaned as aforesaid. (*Accepted June 5, 1918.*)

116,055. Crossley Motors, Limited, Gorton, Manchester, and T. D. Wishart, Heaton Chapel, near Stockport, Internal-Combustion Engines. (2 *Figs.*) February 12, 1918.—This invention relates to valve tappet gear for internal-combustion engines, and comprises the use of a number of additional spring-loaded cams on the ordinary camshaft whose function is to maintain a constant contact between the moving parts of the valve gear, thereby eliminating the chatter and shocks inseparable from the present type of valve tappet gear now in general use. In the improved mechanism two cam discs having

Fig. 1.

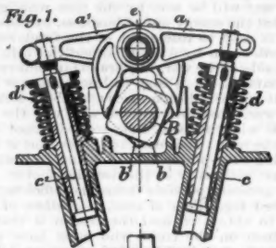
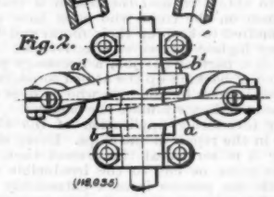
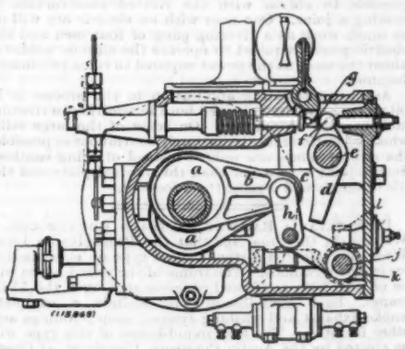


Fig. 2.



our cams fac es each (in the case of a four-cylinder engine) and two spring-loaded plungers are employed, the counterbalancing load of the springs being transmitted by means of two levers from the spring plungers to the cams. *a*, *a1* are two rocking levers which bear on the cam discs *b*, *b1*, at correctly arranged intermittent periods. The number of cam faces on the discs *b*, *b1*, used on the cam shaft B depends on the number of intermittent shocks imposed by the operation of the valves. The two plungers *c*, *c1*, are loaded by the springs *d*, *d1*, respectively, and the rocking levers *a*, *a1*, are fulcrummed on the pin *e*. (*Accepted June 5, 1918.*)

115,868. A. King, Oulton Broad, and Torbinia Engineering Company (1916), Limited, Oulton Broad, Internal-Combustion Engines. (1 *Fig.*) April 16, 1917.—This invention relates to fuel-pump gear for internal-combustion engines, of the class wherein a cam or eccentric on the engine shaft operates through interposed linkage means whereby one arm of a two-armed lever controlled by the engine governor can be struck at a variable position between its fulcrum and free end so as to lengthen or lessen the time during which the other end of the lever actuates the pump plunger. *a* are two eccentrics set at a suitable angle, say, 180 deg. apart. Each of the eccentrics is provided with a strap *b* which is furnished with a roller *c* for striking a lever *d* fulcrummed on an eccentric journal carried by a spindle *e*, the angular position of which is controlled by a governor of centrifugal or other type. The throw of the eccentrics



and the action of the governor are so arranged that the latter removes the fulcrummed lever out of reach of the rollers *c* when the speed of the engine rises a certain percentage above the normal. The shorter end *f* of the lever *d* is in contact with the head *g* of the pump plunger, and an injection takes place whenever one of the rollers *c* strikes the other end of the lever. The part of the lever struck by the rollers *c* is curved, and each roller can be raised or lowered by links *h* hinged at one end to the eccentric straps *b* and at the other end to an arm *i* keyed on the shaft *j* of a worm wheel *k*. By rotating in one direction or the other the worm *l* which engages with the worm wheel, the roller *c* is raised or lowered, and in consequence strikes the lever *d* nearer to or further from its fulcrum, and the further the point of impact is from the fulcrum the longer will be the period of injection, and the nearer it is to the fulcrum the shorter will be the time during which the injection will take place. (*Accepted June 5, 1918.*)

EXPORTS OF FERRO-TITANIUM FROM THE UNITED STATES.—According to *The Iron Age*, exports of ferro-titanium continued to expand up to October, 1917, but since then they have declined, due to shipping restrictions, though some is still going to Japan. Up to October 1, 1917, exports had been 750,000 lb., which contrasts with 471,500 lb. in the calendar year 1915 and 170,240 lb. in 1914.